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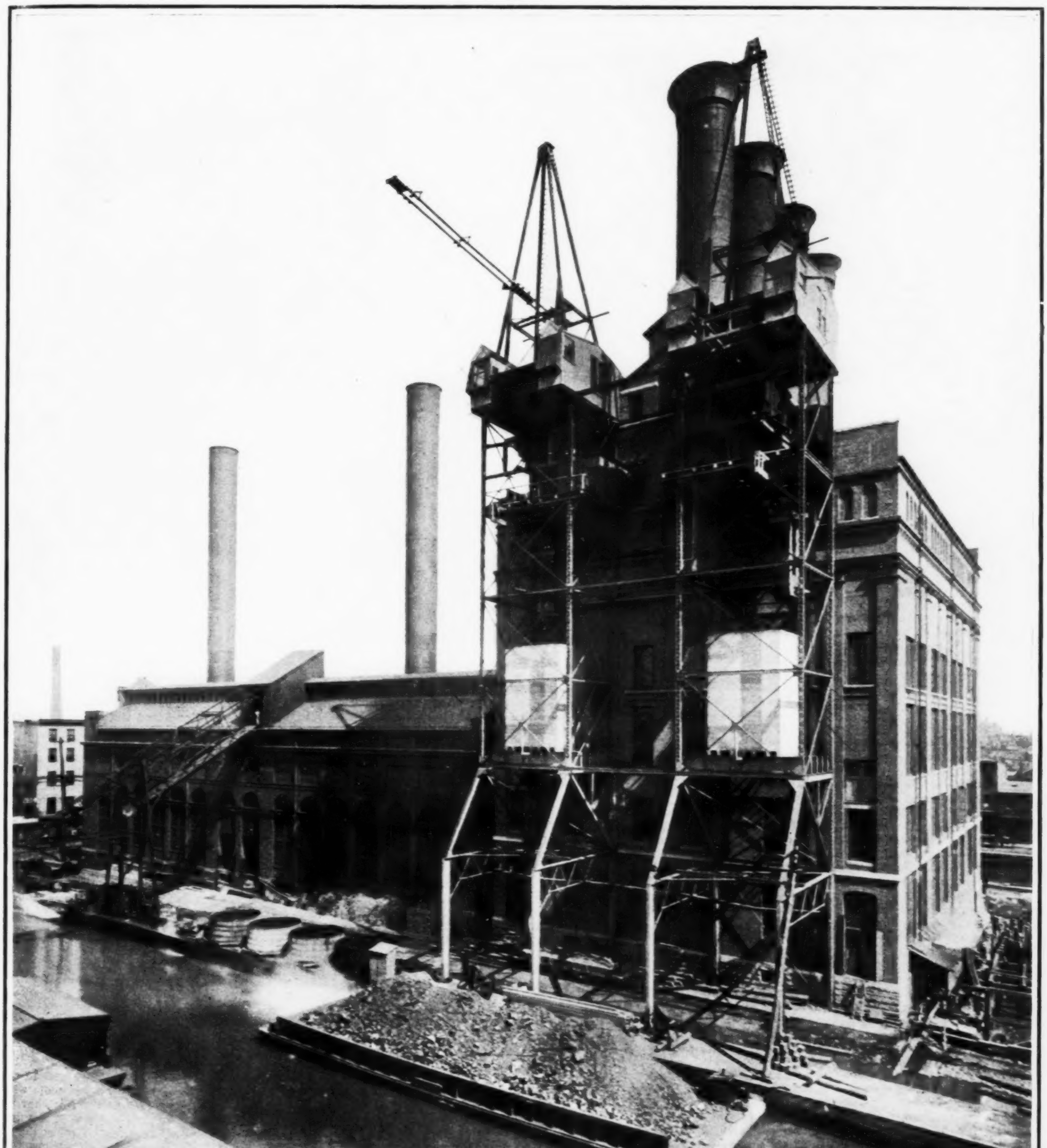


THE BUILDING CONSTRUCTED IN 1895 IS SHOWN AT THE LEFT AND THAT BUILT IN 1902 AT THE RIGHT.

BALTIMORE'S 19,500-HORSE-POWER POWER-HOUSE, SHOWING THE ECONOMICAL COAL-HANDLING PLANT.

AN ECONOMICAL COAL-HANDLING PLANT.

In 1895, the Pratt Street station of the City and Suburban Railway Company, which has since been absorbed by the United Railways and Electric Company, had the distinction of producing current at the lowest price per kilowatt hour of any station in America. It represented the highest development of power station engineering at that time.

Coal was shoveled by hand into coal tubs, which were hoisted by a steam engine. A separate engine was also used for cracking the coal, which was afterward delivered to the coal-storage bin over the boilers by a conveyor. The same conveyor removed the ashes.

Remarkable progress has been made in the last few years. The City and Suburban Railway Company is amalgamated in the United Railways and Electric Company of Baltimore. The Pratt Street station has been increased to 19,500 horse-power, and the new power station, since erected, embodies all the progress of power-house engineering during that time.

The advance in power-house engineering is clearly shown in our illustration, and the handling of coal and ashes has kept pace with the times. The installation at this station is in duplicate throughout.

The great height of the hoist, 151 feet, made the application of electricity as the hoisting power exceedingly difficult, and great credit is due to Mr. P. O. Keilholtz, consulting engineer of the United Railways and Electric Company, for his masterly solution of the problem.

The hoisting machinery is operated by means of a constant current system, that was known as the "turret" system, and consists of a motor-generator set which supplies current to the hoisting motor in the tower. This method gives great smoothness in hoisting and has proved eminently satisfactory in regular operation.

The coal is hoisted from the boats in an electrically operated shovel, thus dispensing with hand labor. The shovel discharges the coal into a hopper, from which it passes through a coal cracker to render it the proper size for use in stokers.

The coal now passes into an automatic railway car which stands on weighing scales in the tower, and is weighed before passing to the bin. The automatic railway distributes the coal into the coal pockets over the boilers, and, as it is a self-acting railroad, the car returns automatically to the loading point, no power being required for its operation.

The coal is drawn from the pockets over the boilers through self-balanced cut-off valves, to the automatic stokers; the ashes pass through similar cut-off valves to the conveyor, and are carried to the ash bin for removal. The conveyor carries the ashes without transfer, as the buckets maintain a horizontal position at all times.

The conveyor is electrically driven. The conveyor driving mechanism imparts an even motion to the chain and entirely avoids sprocket wheel difficulties. The coal and ashes handling machinery is arranged in duplicate throughout, a matter of great importance, and which further illustrates the improvements in power-house engineering.

The coal-handling machinery for both the old and new stations was manufactured and furnished by the C. W. Hunt Company, installed under the direction of Mr. P. O. Keilholtz, consulting engineer of the United Railways and Electric Company.

A VARIABLE-SPEED GEAR.

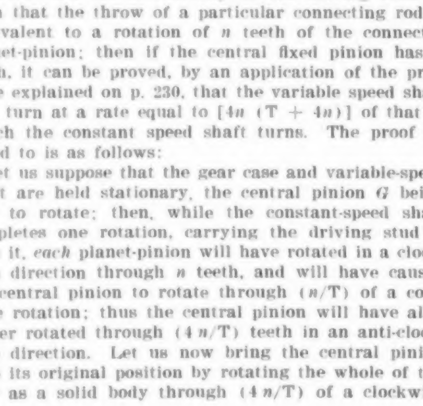
GIVING ALL SPEEDS FROM ZERO TO A MAXIMUM.

Within the last few years numerous speed gears have been put on the market. These have all been alike in one respect, viz., that they give only a limited number of definite speeds; and, indeed, it has generally been believed that a speed gear characterized by a direct drive, and yet capable of continuous adjustment for all speeds, was an impossibility. The "Newman" speed gear, however, successfully accomplishes this result, any speed between zero and a certain maximum value being obtainable by its use. This gear is represented diagrammatically in Fig. 1. The central pinion *G* is fixed; round this revolve four planet-pinions which rotate about studs fixed to the gear case, which in its turn is rigidly connected with the variable-speed shaft. Each planet-pinion comprises two separate parts—an outer annulus with external teeth, and an inner disk rotating freely on the stud fixed to the gear case. The only connection between the inner disk and the outer toothed annulus is effected by a roller clutch arrangement. On the periphery of the disk are four slots containing rollers; each slot on one side is not quite so deep as the diameter of the contained roller, while on the other side it is somewhat deeper than the diameter of the roller. The slots are shown black in Fig. 1. If a disk is rotated in a clockwise direction at a speed greater than that of its surrounding annulus, the roller rolls into the narrower part of the slot, and the disk and annulus run solid; if the speed of a disk is less than that of the annulus, or if the disk is rotated in an anti-clockwise direction, the roller rolls into the deeper part of the slot, and the disk and annulus become free of each other.

Let us now suppose that one of the disks shown in Fig. 1 is rotated backward and forward through a small angle; during the small clockwise rotation the roller clutch is operative, and the annulus is forced to rotate, and consequently rolls through a small distance about the central pinion *G*; in doing so, it carries with it the gear case and the other planet-pinions. During the small anti-clockwise rotation, the roller clutch releases the annulus, so that while the disk returns to its original position the annulus does not follow it. It is thus clear that successive small backward and forward rotations of one of the disks will cause the gear case, and with it the variable-speed shaft, to rotate in a clockwise direction. The way in which the small backward and forward rotations of the disks are produced is as follows:

At the end of the constant-speed shaft is an eccentric stud, shown in section at *A*, Fig. 1. This stud, of course, is in no way connected with the fixed pinion, *G*, but revolves over this in the dotted circle shown. The eccentric stud is joined, by means of four connecting rods, to pins in the central disks of the four planet-pinions; thus, during one rotation of the constant-speed shaft, each disk will effect a forward and backward motion, and the surrounding annulus will be forced to roll a certain distance around the central pinion, *G*. The positions of the connecting rods (represented by thick lines in Fig. 1) are such that, as the roller clutch of one planet-pinion disengages, that of the next pinion engages, and consequently the gear case rotates continuously at a rate dependent on the eccentricity of the driving stud, which can be varied at will. Let the eccentricity of the driving stud be such that the throw of a particular connecting rod is equivalent to a rotation of n teeth of the connected planet-pinion; then if the central fixed pinion has T teeth, it can be proved, by an application of the principle explained on p. 230, that the variable speed shaft will turn at a rate equal to $[4n \div (T + 4n)]$ of that at which the constant speed shaft turns. The proof alluded to is as follows:

Let us suppose that the gear case and variable-speed shaft are held stationary, the central pinion *G* being free to rotate; then, while the constant-speed shaft completes one rotation, carrying the driving stud *A* with it, *each* planet-pinion will have rotated in a clockwise direction through n teeth, and will have caused the central pinion to rotate through (n/T) of a complete rotation; thus the central pinion will have altogether rotated through $(4n/T)$ teeth in an anti-clockwise direction. Let us now bring the central pinion *A* to its original position by rotating the whole of the gear as a solid body through $(4n/T)$ of a clockwise



"NEWMAN" SPEED GEAR.

rotation; then the driving stud *A* and constant-speed shaft will have rotated through $[1 + (4n/T)]$ turns, and the gear case will have rotated through $(4n/T)$ turns; therefore the ratio

$$\frac{\text{Speed of variable-speed shaft}}{\text{Speed of constant-speed shaft}} = \frac{4n}{T + 4n}$$

The Newman speed gear is made by Messrs. Johnson & Phillips, of Charlton, Kent. It was exhibited at the Automobile Exhibition at Olympia, where it attracted much attention. When it is fitted to a motor car, the latter can be made to crawl along at the smallest conceivable speed, or the speed can be gradually increased to a maximum without any discontinuity or shock.—Technics.

THE CONSTRUCTION OF SIMPLE ELECTROSCOPES FOR EXPERIMENTS ON RADIO-ACTIVITY.*

The electrical method, where it is applicable, is now by far the most sensitive method of detecting small quantities of matter; and the recent advances in physical science made by the method of measuring small leakages of electricity, especially in connection with the phenomena of radio-activity, have excited a very general interest in the experimental arrangements employed. The writer hopes that the following account of simple electroscopes for this kind of work will be found to be of a practical nature and of service to those who, though unfamiliar with many of the devices in general use in a physical laboratory, are nevertheless desirous of making quantitative experiments on radio-activity or some other subject where the electrical method is employed.

In general the final shape of the instrument will depend very much on the purpose for which it is required; in fact, it is one great advantage of the gold-leaf electroscope that it can usually be fixed up in any odd corner of the apparatus which happens to be convenient. There is, however, one part of the apparatus which is always the same in sensitive instruments, and that is the gold-leaf system itself. Before describing this it will perhaps make things clearer if we consider for a moment one or two points about the theory of the instrument.

What we observe usually is the rate of decrease of the deflection of a charged gold leaf from a vertical metal support to which it is attached. Now the deflection in question depends only on the shape and size of the leaf and of the metal support, and on the electrostatic potential of the system, so that the rate of collapse of the leaf measures the rate of decrease of the electrostatic potential. But what we wish to measure is the current or rate of alteration of electric charge, and this is equal to the rate of decrease of potential multiplied by the electrostatic capacity of the system. Thus, for a given current, the rate of movement of the gold leaves is greater, the smaller the capacity of the system. For a sensitive instrument it is therefore absolutely necessary to have the parts which are metallically connected with the gold leaf as small as possible.

Cutting gold leaves is a process which requires a considerable amount of patience, especially from the beginner. The process I always adopt is to take a plate of glass and lay a sheet of smooth note paper on it. On this the gold leaf is spread out flat by blowing gently if necessary, and is cut by means of a razor. To do this, all except a narrow strip at the edge is covered with a second sheet of note paper, the straight edge of which is pressed down with the fingers so as to hold the gold leaf. A fine strip outside the edge of the paper is then cut off from the leaf by dragging the razor gently backward parallel to itself and to the edge of the paper. It is not necessary to exert any great pressure during this operation, but a little practice will be necessary to get into the way of doing the saw-cut stroke at the proper speed. Mr. C. T. R. Wilson has succeeded in this way in cutting uniform strips one-tenth of a millimeter across, but for most purposes strips one millimeter wide are good enough. In working with gold leaf much trouble will be saved by working in a room which is free from draughts and disturbances generally.

For the metal support to which the gold leaf is attached it is convenient to use a piece of wire of about the same diameter as the thickness of the gold leaf. To fix the leaf on to the wire it is sufficient just to moisten the latter at the point of attachment with the tip of the tongue; on allowing the end of the gold leaf to come in contact with the very slightly moist wire it will be found to attach itself sufficiently firmly for all that is required of it. For obvious reasons the cutting and mounting of the gold leaf should be the very last operation in the construction of the electroscope.

In constructing an electroscope it is of the utmost importance to have trustworthy insulation. When the apparatus has not to be raised to a high temperature, and great mechanical strength is not required, sulphur is a long way better than anything else for this purpose. Generally speaking, it is better to have as small a quantity of insulating material as possible in order to diminish irregularities caused by the superficial charging up of the dielectric. Suppose we wish to insulate the wire carrying the gold leaf from another wire which supports it mechanically, we should proceed as follows: Take a porcelain crucible and gently heat a quantity of pure flowers of sulphur in it until it just melts and forms a clear yellow limpid liquid. It is important that it should not be heated so strongly as to become dark colored and viscous, as this appears to diminish its subsequent insulating properties. The end of one of the wires is then dipped into the liquid sulphur, when a coating of sulphur forms on the wire. This is allowed to cool until it has solidified, and the operation is repeated a number of times until a bead of sulphur like that shown in Fig. 1 *A* has formed on the end. The end of the other wire is now heated gently in the flame and applied with a slight pressure to the point, *a*, when it melts its way into the sulphur; and if the operation has been successfully carried out the result will be as indicated in Fig. 1 *B*.

In this sort of work it is often necessary to make sulphur stoppers, etc., of various shapes. To do this it is only necessary to make paper models of the required shape, into which the sulphur is cast. The paper generally sticks to the sulphur, but may be taken off with a clean knife without impairing the insulation. It is advisable to do this, and also any cutting away of the sulphur that may be necessary, immediately after it has set, since it becomes very hard and brittle soon afterward.

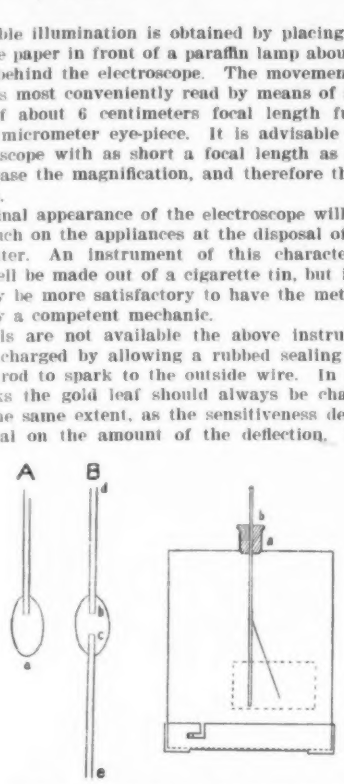
For ordinary work with radio-active substances it is not necessary to employ the most sensitive type of electroscope, and for such work the design shown in Fig. 2 is very convenient. It consists of a brass cylinder of about the proportions shown and 10 centimeters high. The top is closed by a flat plate with a narrow tubular opening, *a*, into which a sulphur stopper, *b*, cast as above, fits fairly tightly. The sulphur is best cast round the wire destined to carry the gold leaf. For examining the properties of various radiations the bottom may be made in the form of a ring, as shown. This is fixed by the slot and pin indicated or some similar arrangement, and the circular hole in the base can be covered with sheets of foil, etc., if it is desired to examine the penetrating power of the rays under investigation. In all these instruments a hole has to be cut in the metal both in front and behind the gold leaf to illuminate it and to read its position. The holes are conveniently of about the relative size shown; they may be covered up with glass, mica, or transparent celluloid, whichever is most convenient.

* Nature.

A suitable illumination is obtained by placing a sheet of white paper in front of a paraffin lamp about twelve inches behind the electroscope. The movement of the leaves is most conveniently read by means of a microscope of about 6 centimeters focal length furnished with a micrometer eye-piece. It is advisable to have a microscope with as short a focal length as possible to increase the magnification, and therefore the sensitiveness.

The final appearance of the electroscope will depend very much on the appliances at the disposal of the experimenter. An instrument of this character could quite well be made out of a cigarette tin, but it would probably be more satisfactory to have the metal parts made by a competent mechanic.

If cells are not available the above instrument is readily charged by allowing a rubbed sealing wax or ebonite rod to spark to the outside wire. In measuring leaks the gold leaf should always be charged to about the same extent, as the sensitiveness depends a good deal on the amount of the deflection. The in-



FIGS. 1 AND 2.—ORDINARY ELECTROSCOPE.

strument will not keep its charge indefinitely, but will show a small leak even if no radio-active substances are present; this is nearly all due to the so-called spontaneous ionization of the air. There is practically no leakage across the sulphur if the instrument is properly made.

For some purposes a more convenient arrangement is that indicated in Fig. 3, where the figure is drawn so as to exhibit the electroscope in its most sensitive form, i. e., with the minimum capacity. A piece about 4 centimeters deep is cut off a wide brass cylinder, and the side tubes fitted on as shown. The gold leaf is carried by the wire, *b*, and is insulated by the sulphur bead, *a*, formed in the manner already described. Thus the insulation leak can only take place to the support, *c*, and can be entirely prevented by keeping *c* at the same potential as *b* by means of cells. The insulation of the wire *c* from the tube which supports it need not be of a very high order; it is sufficient to fix it in with a rubber stopper in the manner shown. So far we have all our charged system inclosed, so that there arises the difficulty of charging it. This is done by means of the wire, *d*, which can be rotated about an axis through the center of the ebonite stopper, *e*. It is advisable to remove the wire *d* from the gold-leaf system when once this has been charged. By means of the sealing-wax handle *f* this may be accomplished without discharging the electroscope. The instrument is so far open. It is conveniently closed by two squares of window glass cemented on to the brass cylinder with sealing wax. The whole of the outside is then covered with thin lead sheet or tin foil to obviate effects due to the glass getting charged. Suitable windows

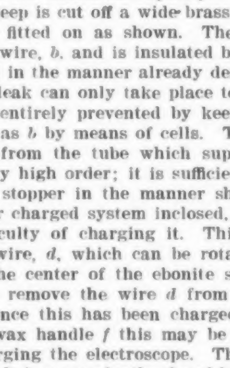


FIG. 3.—VERY SENSITIVE ELECTROSCOPE.

must be cut in this to allow the position of the gold leaf to be read.

The above arrangement is as sensitive as this type of instrument can conveniently be made, since its capacity is only that of a short piece of wire and the gold leaf. Generally speaking, the capacity in electrostatic units is found to be of the same order as the length of the wire. In this or a slightly altered form, the instrument is suitable for experiments on spontaneous ionization and the radio-activity of ordinary materials.

In experiments on emanations, induced activity, and very penetrating rays it is often convenient to increase the magnitude of the effects by allowing them to ionize a large volume of air. For this purpose the arrangement last described is particularly convenient. It is only necessary to solder a long straight wire upon the lower end of *b* and to fix *g* by means of a rubber stopper into the neck of an oil can. The leak then measured is due to the ionization produced throughout the volume of the can. The sensitiveness, though greater than before, is not increased in the ratio of the volumes, as would otherwise be the case, owing to the increased capacity produced by the additional wire. This arrangement is especially useful for examining the induced activity which may conveniently be deposited on the wire.

A still more sensitive type of electroscope was recently invented by Mr. C. T. R. Wilson. It does not, however, appear to be an instrument which can be safely recommended to the inexperienced, so that it scarcely comes within the scope of this article. It is described in the Cambridge Phil. Soc. Proc., vol. xii., p. 135, and may be bought from the Cambridge Scientific Instrument Company. Much further information about electroscopes and electrometers for radio-active work will also be found in Prof. Rutherford's book on radio-activity, chapter iii.—O. W. Richardson.

THE CHEMISTRY OF PATINAS.

By DR. O. N. WITT.

I HAVE worshiped at the shrines of art ever since I began to think, and when I stand before a masterpiece its history awakes to life within me. I see the venerable figures of Titian and Da Vinci, the graceful youth Raphael, the gay cavalier Rubens, each doing his best in his own way, and before my mind's eye the noble work is re-created, not in its present condition, but in the splendid beauty of a new birth. And then I seem to hear the gray wings of the centuries rushing overhead, and to see the work fade under their spell to the dull reality of to-day. Then the questions arise: How did all this come to pass, and what are the inexorable laws that forbid beauty to endure as the master's eye saw and the master's hand created it?

To the sadness of such queries investigation alone can give relief. *Tout comprendre, c'est tout pardonner.* (Full knowledge brings full pardon.) We become reconciled to the destructive forces of nature when we learn how her ruins are made, for then we know that, with her, destruction and creation are identical. Therefore I have not only held in reverence the great works that I have been permitted to see, but I have also regarded them with the eye of an investigator. Thus have come the reflections on gallery tone and patina set forth in these papers.

What I have written about the true patina of bronze and copper is merely the skeleton of our knowledge of the subject. A great deal more may be said, and still more must be left unsaid, because it is not yet satisfactorily proven. This applies particularly to the part played in patina formation by the other metals which are combined with copper in bronze. The explanation already given relates essentially to copper alone, but, though copper is the principal ingredient of bronze, and is also the source of true patina, there can be no doubt that the other metals exert a very great influence on the process of patination, accelerating or retarding it, and making the green layer dark or light, dense or spongy. As, furthermore, the foreign admixtures act differently in different proportions, and strongly affect each other, we are clearly in the domain of pure empiricism, where science has not yet succeeded in formulating definite laws and proving them by experiment.

Zinc is universally regarded as a very injurious and dangerous addition to art bronzes, for it is well known that metallic zinc precipitates copper from its salts, in spongy form. The presence of zinc in bronze would exert a very slight influence of this character upon the patina after its formation, making it porous and inclined to scale. In contrast to zinc, tin, which is a normal constituent of all bronzes, appears to retard the formation of patina and also to make the coating very tough and dense. A very beneficial effect is ascribed, also, to an admixture of silver. This is rarely made now, though old-time artists regarded such additions as their most effective expedients. It would be worth while to determine the proportion of silver in old bronzes with especially fine patina, if only to obtain a definite idea of the value of such admixture. In view of the great decline in the price of silver, there can be no serious objection to its use in art bronzes. On the other hand, we know from the study of antique silverware that silver is the only metal that shares with copper the property of forming a true patina, that is to say, a dense, tough crust very firmly attached to the metal. The coating is blackish gray, occasionally with metallic luster, and usually consists mainly of silver chloride. This seems to prove that with silver, as with copper, the chlorine of sea breezes is the principal agency in patination.

Some bronze contains gold, but this has probably never been added purposely in order to affect the spontaneous patination by wind and weather. The high price of gold restricts its application to small bronzes which are not placed in the open air.

The patina question, which was once ventilated so diligently, appears to have rested in profound calm for several decades. But for this fact it is probable that important results would have been obtained by adding aluminium, now so readily available, to art bronze. In the mechanical arts the alloy of copper and aluminium, known as aluminium bronze, long since established its value. It is distinguished by its beautiful golden color and its permanence in the air. Both of these good qualities are obstacles to the employment of ordinary aluminium bronze in important works of art, for we do not wish our bronzes to remain golden and glittering. The addition of a very small quantity of aluminium to art bronze, however, would probably not prevent the formation of patina, but would rather increase its density and toughness.

Another modern alloy of copper, the use of which in art works is to be strongly recommended, is phosphor-bronze. This material is nearly as strong as steel, and it contains, in its phosphorus, a substance whose gradual oxidation produces the acid required in the formation of patina. The resultant patina would consist chiefly of the beautifully colored and nearly insoluble basic phosphates of copper. These considerations led me, many years ago, to expose a bright piece of phosphor-bronze to the air and observe the progress of patination. I obtained a strong gray-green patina, which opposed astonishing resistance to every attempt to remove it by scouring or "biting."

If I desired to make systematic experiments on the formation of patina, I should select for my first series of test objects alloys containing various small quantities of aluminium and phosphorus in addition to the traditional copper and tin. I believe that among these alloys would be found the long-sought material which would develop a satisfactory patina even in the smoke-impregnated air of central Europe.

And now a word on a very unpleasant subject, namely, the false patina which many mistake for the genuine. It is found on the commercial reproductions of antique art which almost every tourist brings home from Rome and Naples, and sets up in the "best room" as mementoes of days not to be forgotten. When I pass the show windows of the Italian shops that drive a flourishing trade in these copies, I often recall an experience of twenty years ago, in the flush of my enthusiastic first love of the Tanagra statuettes in the Saburow collection, which had just been purchased for the Berlin museum. Their childlike *naïveté* and grace quite won my heart, and I hastened to a well-known shop and asked for plaster copies. Casts were shown me in abundance, but the charm of the originals was entirely lacking. The boldly-executed figurines had become smoothly pretty dolls, whose artistic value was about on a par with that of a Thuringian porcelain angel. I could not help expressing my astonishment. "Yes," said the shopkeeper, proudly, "I have improved them very greatly. The originals are horribly crude." Tanagra copies of this sort have since been replaced in the market by others less thoroughly "improved."

"Improved" imitations of the Narcissus, the Dancing Faun, and many other gems of the golden age of Greco-Roman art form a very lucrative article of commerce with the enterprising Italians. Like the originals, they have patina, but even this has not escaped improvement, and confronts the world with a glare of deadliest green.

This false patina is not invariably composed of oil paint, daubed on lavishly and wiped off the prominent parts with a rag. Oh, no! Occasionally one finds a real copper patina, produced by taking advantage of the fact that copper and all its alloys are attacked by ammonia in presence of atmospheric oxygen. Formerly the bronzes were placed near a dunghill, where they acquired a beautiful patina in a few days; but now that they are turned out by wholesale, they are probably fumed with ammonia in rooms constructed for the purpose. Some of them may be simply brushed with weak ammonia water thickened with gum. The resultant patina consists of ammonio-carbonate of copper, but, as this salt is too blue for the taste of most "connoisseurs," there is usually a subsequent treatment with dilute acetic acid, which forms basic acetates of more greenish hue. All these varieties of patina have the defect of solubility, and, consequently, they would soon vanish if exposed to the weather. But, in the first place, such bronzes are not placed out of doors, but in the best room; and in the second, there is an admirable modern invention in the shape of a protective varnish, which is eminently fitted to confer a certain resistance to moisture upon objects painted with it, so that the finished Narcissus, patina and all, may even be wiped with a damp cloth without injury.

By the above I do not mean to imply that very good bronze copies of antique works are not to be found in Italy. The Italians enjoy a well-deserved reputation as skillful bronze founders, but they are equally skillful as merchants, and they sell each customer the sort of bronze he deserves. *"Il y en a pour tous les goûts!"* ("We have them to suit all tastes!") the Roman shopman of the Piazza di Spagna said to me, with an expressive gesture. But whether the bronze is good or bad, the patina is not of the right sort, and it cannot be, for true patina is a patent of nobility written by the years and signed by the centuries.

Ought we to rejoice or regret that genuine patina can not be produced, artificially and quickly? I think that we may well be content with things as they are; for if nature had not happened to make basic copper salts blue-green, there would not be the slightest artistic motive for giving bronze a green surface. The artistic effect produced by the coating when it has come spontaneously, the mellowing of the garish glitter and aggressive color of the bright metal, may be obtained very well in other ways. Indeed, there is an absurdity in bronzes covered with green patina standing indoors, where true patina can not form. In such locations the gray-blue-green patina is not even beautiful, to my eyes, though a fine patina on copper roofs and bronze statues gives a city an air of great distinction.

For the unpleasant glare of bronze objects intended for indoor decoration we have an excellent remedy in fire patina. This is a colored and firmly adhering coating, which is produced by strongly heating the bronze for a considerable time. The metals are oxidized in the process, and the layer of oxides, if it is not allowed to become too thick, adheres with remarkable tenacity.

It might be imagined that a metal treated in the open air would be exposed to an excess of oxygen, and

consequently raised to its highest state of oxidation, but this is not the case. At any given moment the action between metal and oxygen is necessarily confined to the thin layer of oxygen which is in immediate contact with the metal. This is very small in comparison with the metal exposed, and for this reason the lower oxides are chiefly formed in all cases of oxidation of metals by heating. Iron develops, not the beautiful red sesquioxide (peroxide), but the pitch-black magnetic oxide.

When copper is heated, the red cuprous oxide first appears, but at high temperatures some black cupric oxide is formed also. The colors of these compounds, however, do not matter in the first stage of the process, for the exceedingly thin coating affects the eye, not by its proper color, but through its character as a thin plate, giving rise, for example, to the familiar and beautiful tints of tempered steel. The tempering colors of copper and bronze, which are less often seen, are even more beautiful and brilliant, for the proper color of the metal shines through and blends with them.

When copper or bronze is heated for a longer time or to a higher temperature than is required for the production of tempering colors, the layer of oxide becomes thicker, reflects its proper color, and is called fire patina. In its manifold gradations it offers a beautiful and certainly the best and most natural means of softening and mellowing the offensive glitter of the bare metal.

Large bronze figures intended for open-air monuments cannot be coated with fire patina, because they cannot be placed in kilns and heated gradually to the requisite temperature. For them true patina, which may also be called weather patina, will ever remain the natural artistic finish.

In the production and estimation of fire patina, as in so many other branches of art, the civilized nations of eastern Asia, the Chinese, and especially the Japanese, have been our teachers. The Japanese first discovered that differences in the composition of bronze strongly influence the character and color of fire patina, and they have made admirable use of the discovery. By adding antimony to their bronzes they obtain black and dark brown tones, while the highly-esteemed warm red-brown shade is produced most easily on bronze which contains a little gold. The material of many small Japanese bronzes proves to contain gold, and a skillful European worker in bronze has assured me that he can secure certain effects for which his work is celebrated only by the aid of this costly ingredient.

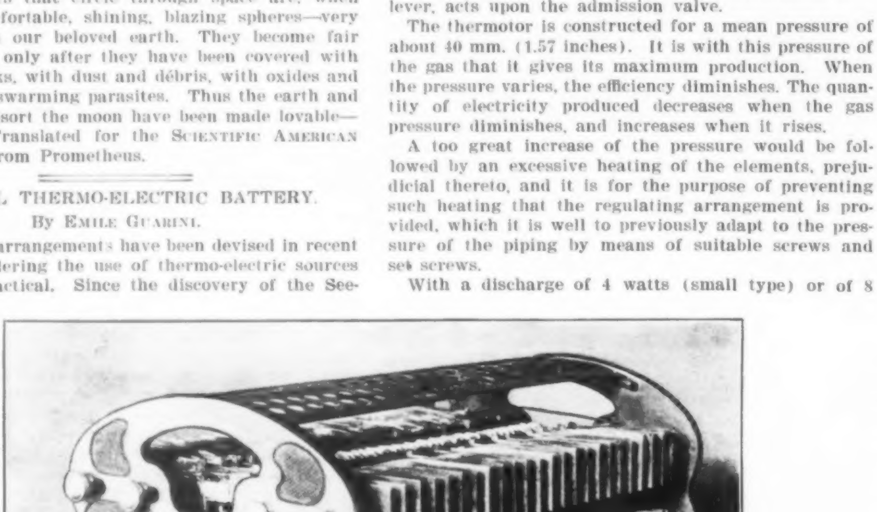
With the consideration of fire patina we have reached the end of our subject. In fire patina we have an example of the possibility of obtaining, under conditions which increase the activity of the effective agents, results similar to those of age.

As it is the task of art to create inspired images of nature, so the processes of patination to which these images are subject from their birth are symbolical of the changes wrought by time in all created things. Even the stars that circle through space are, when "new," uncomfortable, shining, blazing spheres—very different from our beloved earth. They become fair and habitable only after they have been covered with rifts and cracks, with dust and débris, with oxides and hydrates and swarming parasites. Thus the earth and her gentle consort the moon have been made lovable—by patina!—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Prometheus.

A NOVEL THERMO-ELECTRIC BATTERY.

By EMILE GUARINI.

VERY many arrangements have been devised in recent years for rendering the use of thermo-electric sources of current practical. Since the discovery of the Seebeck and Peltier effects, endeavors have been made, but unfortunately without satisfactory results, to construct a generator of the kind under consideration, the consumption of which should not be excessive.



THE THERMOTOR.

The great losses of heat, through radiation especially, and through conductivity, are, as we know, the causes that have intervened to prevent such apparatus, which run so regularly, are so easy of maintenance and so clean in their operation, from getting beyond the laboratory.

Some very good types have nevertheless been constructed, although their operation is as yet costly, and their efficiency not very high. This, in the best generators, among which may be mentioned those of Noé, Rebizek, Clamond, Chaudron, and Gülcher, scarcely exceeds a few thousandths. There is, therefore, a great loss of energy, which is due, aside from losses by radiation, to the great quantity of heat that is carried along by the gases resulting from combustion.

Despite such acknowledged inadequate efficiency, thermo-electric batteries are still quite frequently employed, say in chemical laboratories, and for electro-metallurgic purposes, etc., by reason of their constancy, their regularity, their cleanliness, and the small amount of attention they require.

As a general thing, very neat and, upon the whole, but slightly cumbersome thermo-electric batteries—particularly those heated with gas and kerosene—are extremely safe.

The generators heated with gas are the ones now most employed, those heated with kerosene and charcoal being scarcely any longer used except in cases where there is no supply of gas available.

It is for heating with gas that has likewise been constructed and recently put upon the market by a German firm a type called the "thermotor."

The arrangement of this battery is very interesting. The generator consists of four rows of elements disposed in pairs, on each side of two heating frames. The linear expansion of the latter is the principle upon which is based the regulation with which apparatus of this kind is provided. Under the influence of heat, the frame expands and, through the intermedium of a lever, acts upon the admission valve.

The thermotor is constructed for a mean pressure of about 40 mm. (1.57 inches). It is with this pressure of the gas that it gives its maximum production. When the pressure varies, the efficiency diminishes. The quantity of electricity produced decreases when the gas pressure diminishes, and increases when it rises.

A too great increase of the pressure would be followed by an excessive heating of the elements, prejudicial thereto, and it is for the purpose of preventing such heating that the regulating arrangement is provided, which it is well to previously adapt to the pressure of the piping by means of suitable screws and set screws.

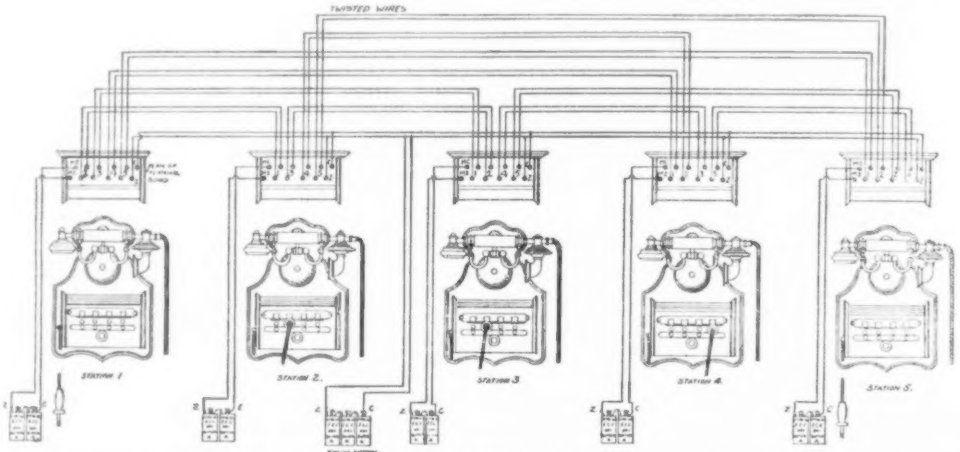
With a discharge of 4 watts (small type) or of 8 watts (large type) the consumption rises to 100-110, 200-220 liters an hour (3.53-3.88 or 7-7.6 cu. ft.).

As in all apparatus of this kind, the pressure of the feed-gas has an important influence not only upon the consumption, but also upon the life of the apparatus. It is desirable, from all points of view, that the thermo-electric elements shall not be overheated, and that the admission shall be regulated once for all, afterward allowing the regulator to complete the regulation according to requirements.

When it is properly operated and treated, the thermotor possesses all the stability that could be expected of a thermo-electric generator, and constitutes a very recommendable source of electricity for the special uses for which it is designed, viz., electro-metallurgy, thermo-chemistry, medical applications, telegraphy, telephony, signaling, and charging of small batteries, accumulators, etc.

A NEW SECRET SERVICE TELEPHONE.*

By the English Correspondent of SCIENTIFIC AMERICAN.



SECRET SERVICE TELEPHONE. PLAN OF WIRING SYSTEM, SHOWING HOW COMPLETE SECRECY IS SECURED BETWEEN ANY TWO STATIONS.

A NEW system of intercommunication telephone, the most salient characteristic of which is that absolute secrecy and privacy are secured while conversation is being maintained between two persons, has been introduced by the General Electric Company of Great Britain. Several attempts have been made for the purpose of surmounting what has hitherto been considered one of the inherent defects of the telephone, i.e., interruption and tapping of the line while conversation is in progress. The majority of such experiments, however, have proved futile, owing to the resulting instruments being too complicated in design, and therefore impracticable.

In this latest device it is absolutely impossible for any tapping, interruption, overhearing, or leakage to take place. Two stations cannot be rung up simultaneously, even by accident, through careless placing of the switch, as in the majority of instruments. The instrument possesses several important novel developments of telephone work, and is somewhat a departure from the usual type. Moreover, it is perfectly simple in its design, with a minimum of working parts liable to derangement.

Arranged along the base of the instrument are a number of drop indicators, corresponding with the number of lines connected therewith, and immediately below these are the "jacks" or plug sockets. The connecting plug carrying a length of flexible cord is inserted into any "jack," according to the line it is desired to communicate with. When a call is made, the indicator corresponding with that particular line falls, denoting at once who it is that is calling. In the event, however, of the room being vacant at the time of the call, the indicator serves a very useful purpose, as it clearly denotes, when the person returns, who it is that has rung him up. Secrecy is insured by the provision of a complete metallic circuit to each pair of stations.

The method of operating the service is simple in the extreme. The operator can place himself in direct communication with his correspondent at any other station by the simple insertion of the plug into the desired "jack," and pressing a ringing key. At the other end of the line a distinct signal is given by the falling of the indicator shutter, which serves to point out the particular station that is ringing up, attention being attracted by the ringing of the bell. Should, however, the plug happen to be left in the "jack," a buzzer comes into operation and fulfills the same purpose.

The accompanying diagram indicates the principle of wiring a series of stations upon this system. In this particular instance a five-line installation is shown, in addition to the terminal board apart from the instrument itself, for the purposes of clearly demonstrating the method of connection.

Station No. 1 is shown in the normal position, No. 2 is in communication with No. 3, and No. 4 is in the act of ringing up No. 5. The operation is carried out as follows: No. 4 station desires to call up No. 5. The plug is inserted in the jack corresponding to that number, and the ringing key is depressed. This causes the shutter No. 4 to drop at station No. 5, completes the local-bell circuit, and announces the call. The dropping of the shutter at once indicates who it is that is calling, and the correspondent at No. 5 inserts his connecting plug in No. 4. Directly the "hand-coms" are removed from their cradles, the two persons are instantaneously placed in direct communication, and it is absolutely impossible for an operator at any other station to interrupt or overhear what is transpiring between the two conversationalists. Should, however, No. 1 call up No. 5 while the latter is talk-

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

ing to No. 4, the shutter corresponding to No. 1 station drops on the board at No. 5. Nothing further takes place and the existing communication remains complete. The drop shutters are automatically restored when the plugs are inserted in the jacks.

On the completion of a conversation, the "hand-coms" are restored to their respective cradles, and the plugs withdrawn from their jacks. Should, however, one correspondent inadvertently leave his plug in the jack, he can still be called by the number of station corresponding to that particular jack by means of the buzzer placed within the instrument.

The system of arranging the necessary external connections is clearly shown in the diagram, which is a plan of the connection boards, all the external connections being shown in full lines consisting of twisted lines. One ringing battery is utilized for the whole system, this battery comprising three dry cells for a short-line installation, with additional similar cells according to the length of the lines. A pair of twin wires to form a battery main is run to each station, the ringing battery being placed at any station according to which is most convenient for the purpose. One very prominent feature of this arrangement is that the ringing battery and its connections are kept entirely separate from the speaking battery and its connections. The speaking battery consists of two dry cells, a separate battery being placed at each station. The employment of the metallic circuit throughout disposes of all possibilities of leakage, while the inductive effects existing in ordinary systems are entirely eliminated.

This secret service telephone can also be adopted as a central station for intercommunication between outlying stations. The latter may be located at considerable distances, and in the event of its being deemed too expensive to connect each with a separate cable of the requisite size, it is possible to employ a single pair of lines between the outlying stations and the central station, thus economizing the cost of wiring. When adopted for this purpose, the instrument is provided with a pair of special plugs, which enable the calling station to be connected through to any other station on the system. It will be observed furthermore that junction boxes are entirely dispensed with.

This system is particularly adapted to government offices or other similar conditions where secrecy between any two departments at time of conversation is a particular desideratum. Conversation is loud and clear, and the instrument can never be left out of call.

ARMOR-PLATE TESTS FOR THE LATEST JAPANESE BATTLESHIP.

By Our English Correspondent.

There is now in course of construction at the shipyard of Sir W. G. Armstrong, Whitworth & Co., Limited, of Elswick, Newcastle-on-Tyne, the battleship "Kashima" for the imperial Japanese navy, and which when completed will be the most powerful vessel afloat, excelling the "Mikasa" and other powerful vessels of the same navy, which are at present in active service.

The trials of the armor plate with which the vessel is to be protected were recently carried out at the Armstrong armor-plate works at Manchester, of which the accompanying photograph illustrates the results. The tests were carried out before Capt. K. Iwanoto, representing the Japanese government. The plate used in the trial was of the usual size, measuring 8 feet in length by 8 feet in breadth, 8 inches in thickness, and weighing 360 pounds per square foot. For the purposes of the test it was backed with 2 feet of oak, and followed by another thin steel plate corresponding to the skin of the battleship. The Firth projectiles used in this test were discharged from a 9.2-inch gun, and the shells were supplied by the British government to the Japanese authorities. These shot are considered by the British government as equivalent to Holtzer in quality. The weight of the projectile in each case was 380 pounds.

The first round was fired with a striking velocity of 1,814 foot-seconds, equal to a striking energy of 8,868 foot-tons, and struck the plate at the left top corner. The result was a maximum penetration of 3.1 inches, about one-third of the thickness of the plate, and the flaking caused by impact is shown in the photograph. The back was bulged only to the extent of 1.9 inches high. The projectile was broken up into 155 pieces, the largest of which was 35 pounds. The total weight of the fragments recovered was 208 pounds.

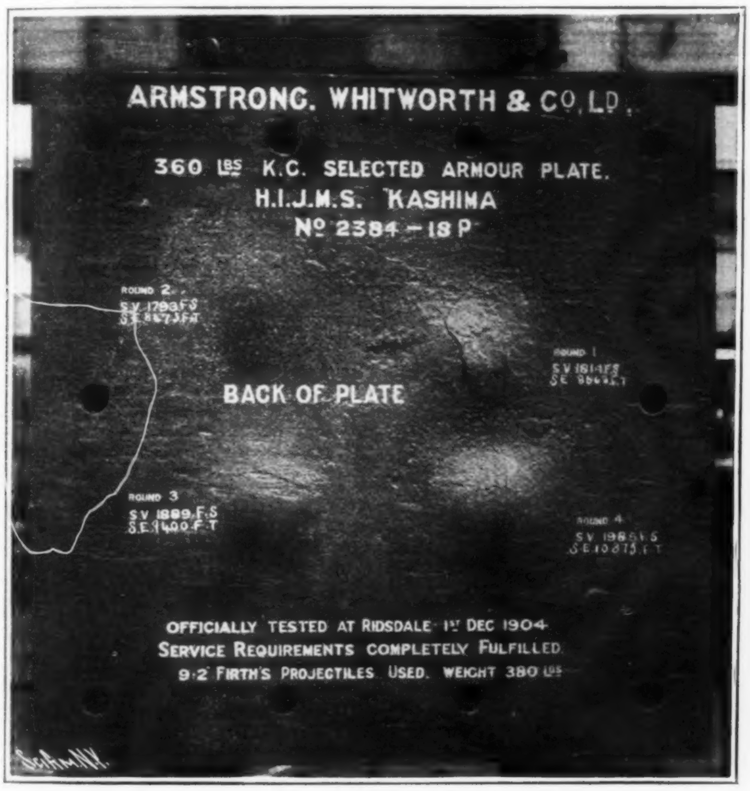
Round No. 2 was fired with a striking velocity of 1,795 foot-seconds, equal to a striking energy of 8,475 foot-tons, and struck the plate at the top right-hand corner. This round gave a maximum penetration of 1.25 inches. On the back of the plate a bulge 1.5 inches high was produced. The fragments of shot recovered weighed 175 pounds. This shell, it will be noticed, had less penetrative effect on the plate. At this stage the plate was formally accepted as satisfactory by the Japanese government, but two further rounds were fired, to demonstrate the actual resistance of the plate.

The third round was fired with a striking velocity of 1,880 foot-seconds, equal to a striking energy of 9,400 foot-tons, causing a similar penetration to that produced by the first round, viz., 3.1 inches, but accompanied with less flaking. The bulge on the back of the plate was 1.9 inches. The projectile was badly broken up, 172 pounds being recovered, of which the largest piece weighed 12 pounds.

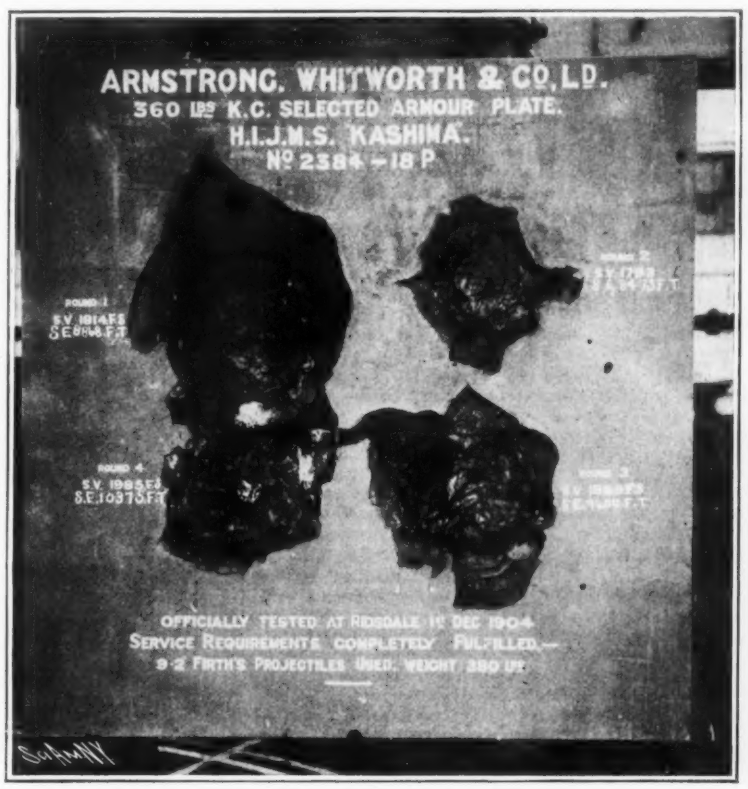
The fourth round was fired with a striking velocity of 1,985 foot-seconds, equal to a striking energy of 10,375 foot-tons. The penetration of this round was not measured, as the point of the shot adhered to the plate, as may be seen in the photograph. The bulge produced at the back of the plate was 2.5 inches high. The remainder of the shot was broken up, 183 pounds being recovered, the largest piece of which was 39.5 pounds. With this last round the highest striking velocity was obtained. At the conclusion of the trial no surface or through cracks were developed, and the quality of the plate was proved to be excellent.

This plate more than fulfilled even the rigid British Admiralty requirements, in which, if a round fired at 1,900 foot-seconds striking velocity proves to be above the resistance of the plate, the velocity is reduced. In this case the plate stood 1,985 foot-seconds in the fourth round. It is also a condition of acceptance by the British Admiralty that no serious cracking of the plate is to result, and no portion of the plate or projectile is to be driven completely through the backing.

How the crack which may be seen on the rear side of the plate was produced is not known, but it was probably the effect of the higher striking velocity of the last projectile. In view of the fact that the plate had already been severely attacked by three previous shots at a high velocity, it is not surprising that the abnormal strain set up by the last round should produce such a crack.



BACK OF PLATE, SHOWING SLIGHT BULGING.



FRONT OF PLATE, SHOWING IMPACT POINTS OF FOUR ROUNDS.

THE NEW JAPANESE BATTLESHIP "KASHIMA'S" ARMOR-PLATE TESTS.

QUANTITY OF COTTON GINNED IN THE UNITED STATES.

The Bureau of the Census has just issued the final report on the cotton crop grown in 1904. This report is No. 19 in the series of census bulletins. The statistics for 1904 are accompanied by comparative statistics for the crops of 1900, 1901, 1902, and 1903. Six preliminary reports were issued during the ginning season of 1904-5, showing the quantity of cotton ginned to specified dates. The final report aggregates the quantities included in each of the preliminary statements, and completes the sixth consecutive crop year for which cotton reports have been published by the Census Bureau.

The crop of 1904, as returned by the ginners, and including linters, is 13,584,457 bales, of 500 pounds. It exceeds the crop of 1903 by 3,491,386 bales, or 35.4 per cent. The largest crop produced in the United States prior to 1904 was that of 1898, which, according to commercial returns, amounted to 11,235,000 bales, or 15.9 per cent less than the crop of 1904. The average crop for the five-year period ending with 1903 was 9,892,047 bales, or 25.9 per cent less than the crop of 1904.

Among the cotton-producing States Texas has held the first rank for twenty years. Its production in 1904 was 3,134,677 bales. Georgia, with a production of 1,960,151 bales, was second, having passed Mississippi, which held the second rank in 1903. Mississippi is third and Alabama fourth. With the exception of Kansas, Arkansas, and Texas, all the cotton-producing States show larger crops for 1904 than for any other year in which these reports have been issued. The States which show the most notable increases compared with 1903 are Alabama, Georgia, and South Carolina, the largest increase being found in Georgia, where the crop exceeded that of 1903 by 612,380 bales, or 48.3 per cent. The increase in Alabama is 46.5 per cent, in South Carolina 45.7 per cent, and in Texas 27 per cent. The largest crop ever grown in Texas was that of 1900, when the State produced 298,870 bales more than in 1904. The increase in the combined productions of Oklahoma and Indian Territory over 1903 is 72 per cent.

The number of local cotton weighers who reported to the Bureau of the Census was 1,372. Much care has been taken by the Bureau of the Census to secure accurate average bale weights, and the returns have been compared with the computations made by Mr. Henry G. Hester, secretary of the New Orleans Cotton Exchange, who computed the average weight of commercial bales, marketed between August 31, 1904, and March 1, 1905, at 519.87 pounds, while the average weight of the bale exported was 516.96. The adoption of the averages compiled by Mr. Hester would of course result in some variation in the total number of bales produced.

The Sea Island cotton crop of 1904 amounted to 104,317 bales, equal to 41,180,434 gross pounds, an increase over the crop of 1903 of 44.3 per cent. This increase is distributed between three States which produce this cotton—Florida, Georgia, and South Carolina. The average crop of Sea Island cotton for the five-year period ending with 1903 was 34,120,844 pounds. The

crop of 1904 is 20.7 per cent greater than the five-year average, and is the largest crop ever grown in the United States, the next largest being the crop of 1902, when the production reached 40,413,053 pounds.

The total number of establishments which ginned some part of the cotton crop of 1904 was 30,337, or 92.3 per cent of the total number of ginneries reported. Three States reported over 4,000 active ginneries—Georgia, Mississippi, and Texas. The total number of the active ginneries in the States mentioned was 13,480, or 44.4 per cent of the total, and they ginned 50.8 per cent of the total cotton production in the United States for 1904. The Census figures show that the average number of bales ginned by active establishments was 445, compared with 338 in 1903 and 358 in 1902. The cotton ginning industry is much more developed west of the Mississippi River than east of it. Texas, with 14.6 per cent of the number of cotton ginneries, ginned 23.5 per cent of the total product, while Georgia, with 16.4 per cent of the total active ginneries, ginned but 14.1 per cent. The crop of 1904 was ginned in 830 counties in 16 States. Of these counties 739 were canvassed by 667 local agents of the Census Bureau, and 99.5 per cent of the total crop of 1904 was ginned in the territory thus canvassed. Ninety-one counties were canvassed by mail, and in these were located 184 active ginneries, which ginned but one-half of 1 per cent of the crop. The average date of the completion of the final canvass was March 10, 1905.

The six preliminary reports of the quantity of cotton ginned, issued by the Bureau of the Census during the past season, cover the quantity of cotton ginned to September 1, October 18, November 14, and December 13, 1904, and January 16, 1905. The final report now issued in Bulletin 19 presents the total quantity ginned during the season.

A feature of much interest discussed in this bulletin is the growth of the cotton-seed industry, indicated in the supplemental report of the linter product of the cottonseed-oil mills. The number of these mills has increased from 357 in 1900 to 715 in 1904, an increase of 100 per cent.

The bulletin just issued comprises forty-two pages of text and tables, in addition to which are presented outline maps of each of the principal cotton-producing States, upon which the crop of 1904 is shown by counties.

STELLAR BRIGHTNESS AND DENSITY.*

By J. E. Gore, F.R.A.S.

The absolute brightness of a star, or its so-called "magnitude," depends on three factors—(1), its distance from the earth; (2), its diameter; and (3), its intrinsic brilliancy, or the actual luminosity of its surface per unit of area. The first of these factors—the distance from the earth—has, in a few cases, been determined with considerable approach to accuracy, either by micrometrical observations of comparison stars, or from spectroscopical observations of binary stars. The second factor—the actual diameter of the star—is more difficult to determine, and its measurement has not been satisfactorily accomplished, except in some variables of the Algol type. An approximation to its probable value may, however, be arrived at from other considerations. The third factor—the luminosity of the star's surface—may be inferred—to some extent at least—from the character of the star's spectrum. This luminosity of surface, or intrinsic brightness, as it is also called, probably depends on the mass and density of the star. Two stars may have the same mass, but one may have a large diameter and small density, and the other a smaller diameter and greater density. The difference is probably a function of temperature. And then the question arises, which of the two stars will be apparently the brighter? We know that heat causes a mass of gas to expand, and the greater the heat the greater the expansion. And with a given mass, the greater the expansion the smaller the density will be. This is evident. Hence a star with a high temperature will have a large volume and small density. And it seems highly probable that the higher the temperature the greater will be the luminosity of its surface. From this it would follow that a star with a high temperature would have a large volume and light-giving surface, and also a greater luminosity of surface, and both causes would thus combine to increase its apparent brilliancy. This would not, however, apply to the nebulæ, but only to bodies, like the stars, which have consolidated to a certain extent.

It is now usually admitted that stars with the Orion type of spectrum (B, Pickering), such as Bellatrix (γ Orionis), δ, ε, and ζ Orionis, are—with the possible exception of the "Wolf-Rayet," or bright line, stars—the most luminous among the brighter stars. Next to these come stars with the Sirian type of spectrum (A, Pickering), followed probably in decreasing order of surface luminosity by stars of the second (or solar) type, and then by the third and, perhaps, the fourth type stars. The "Algol variable" U Ophiuchi has a spectrum of the Orion type, and some of the other "Algols," such as Algol itself, λ Tauri, and V Puppis, show a spectrum intermediate between the B and A type. These will be considered further on.

The probably great luminosity of stars with the Orion type of spectrum is shown by the fact that Sir David Gill finds that the parallax of Rigel is almost certainly not more than the hundredth of a second of arc, and yet it is one of the brightest stars in the heavens; seventh in order of brightness, according to the Harvard photometric measures. At the vast distance indicated by this minute parallax our sun would be reduced to a star of about the tenth magnitude, and would, therefore, be invisible even with a binocular field glass. Rigel is, therefore, about 7,800 times brighter than the sun would be if removed to the same distance. It has a small companion of the eighth magnitude, but as the pair have not yet been proved to be a binary (although the companion itself, which is double, probably is), we cannot determine its mass. But it is evident that it must be a body of enormous size and great luminosity of surface to shine as brightly as it does at such a vast distance from the earth—over 300 years' journey for light. Comparing it with Sirius, whose mass and parallax have been well determined, I find that the mass of Rigel is probably about 20,000 times the sun's mass.

The great brilliancy of stars with the Sirian type of spectrum is shown by Sirius itself, the distance of which is now well determined. From its apparent brightness and parallax I find that Sirius is about 31.6 times brighter than the sun would be at the same distance. From the orbit of its satellite Dr. See finds the mass of the bright star to be 2.36 times the sun's mass, and from this it follows that its real brightness is about 18 times greater than that of the sun in proportion to its mass. Its spectrum shows that it is probably at a higher temperature than our sun. Its volume is, therefore, probably larger, and, as Dr. See says, there "is some reason to suppose that Sirius is very much expanded, more nearly resembling a nebula than the sun." But here the question suggests itself, Is its greater brilliancy due to its larger volume, and, therefore, smaller density, or to its greater surface luminosity, or to both causes combined? As it is 31.6 times brighter than the sun, a diameter equal to the square root of 31.6, or 5.62 times the sun's diameter, would give the necessary brightness, *if* the surface luminosity of Sirius and the sun were the same. Assuming this for a moment, I find that with a diameter of 5.62 times the sun's diameter—or about five millions of miles—its volume would be 177 times the sun's volume, and its density only 0.019 (water = 1). This seems improbable, judging from the known case of Algol, which has a much higher density than this. We may, therefore, conclude, I think, that the great brilliancy of Sirius is probably due to both causes combined—namely, a somewhat larger volume and a greater luminosity of surface than the sun, both probably due to its higher temperature. If we assume its density to be the same as that of Algol, say 0.34, we have the diameter of Sirius about 1,860,000 miles, and its luminosity about seven times that of the sun.

The well-known double star, Castor (α Geminorum), has a spectrum of the same type as Sirius. The orbit is rather uncertain, but Dr. Dobeeck has recently found a period of 346.82 years, with a semi-axis major of 5.756 sec. A doubtful parallax of 0.198 sec. was found by Johnson. From these data the mass of the system would be only 0.2042 that of the sun. In 1894 the fainter component of the pair was found by Bélopolsky to be a spectroscope binary with a period of about 2.98 days, and an orbital velocity of 20.7 miles a second, the companion being relatively dark. If we assume that the components of the spectroscopic pair are equal in mass I find that its mass would be 0.0911 of the sun's mass. Now as the brighter star of the *visual* binary is one magnitude brighter than the companion, its mass would be—if of the same surface luminosity—four times that of the other, or 0.3644. Hence the total mass of the system would be 0.0911 + 0.3644, or 0.4555 of the sun's mass. We may, therefore, conclude from the spectroscopic observations that the mass of the system is comparatively small. Assuming the masses found above, namely 0.0911 and 0.3644, the areas of their surfaces would be 0.2024 and 0.5102, or a total surface of 0.7126. Now the mass of Sirius being 2.36, its relative surface would be—if of the same density as Castor—1.7726. Hence the surface of Sirius would be 2.487 times that of the combined surfaces of Castor's lucid components. But Sirius is 3.16 magnitudes (1.58 + 1.58) brighter than Castor. From these data I find that the parallax of Castor would be about 0.136 sec., which does not differ widely from the result found by Johnson. The brighter component of this interesting pair has recently been found at the Lick Observatory to be also a spectroscopic binary, but the period has not yet been determined. The fact that *both* components are spectroscopic binaries makes Castor one of the most remarkable objects in the heavens.

For δ Equulei, a binary star with the very short period of 5.7 years, Hussey finds from spectroscopic measures a parallax of 0.071 sec., and a combined mass of 1.89 times the sun's mass. He says, "The components of the pair are slightly unequal in brightness, and, perhaps, also in mass. One may be as massive as the sun, but it cannot much exceed it."* The parallax found by Hussey would, I find, reduce the sun to a star of 5.81 magnitude, and as the photometric magnitude of δ Equulei is 4.61, we have the star 1.20 magnitude, or three times brighter than the sun. Assuming that the masses of the components are 1.00 and 0.89 (as suggested by Hussey), I find that if the surface luminosity of each were equal to that of the sun, the combined light of the two components would be 1.9247, or nearly twice the sun's light. The star's spectrum is of the type F, probably indicating a somewhat brighter sun than ours. The difference in the results found above is, therefore, not inconsistent with the parallax found by Hussey. A comparison with Procyon is also confirmatory of Hussey's result.

Let us now consider the case of the bright star Procyon, which has a spectrum F 5 G, or intermediate between that of δ Equulei and the sun. The parallax is about 0.325 sec., and the mass of the system is, therefore, from Dr. See's orbit of the satellite, 3.627 times the sun's mass, that of the bright star being about three times the mass of the sun. At the distance indicated by the parallax the sun would, I find, be reduced to a star of 2.51 magnitude, and as the magnitude of Procyon is 0.48, we have the star 2.03 magnitude, or 6.487 times brighter than the sun. As, however, the mass of Procyon is three times the sun's mass, the star should be, if of the same density and surface luminosity, 2.08 times brighter than the sun. Hence it follows that Procyon is really $\frac{6.487}{2.08}$ or 3.1 times brighter than our sun in proportion to its mass. This may be due either to a larger size, and, therefore, less density than the sun, or to a greater luminosity of surface per unit of area. Probably both causes combine to produce the increased brilliancy, and the result seems to agree well with the star's spectrum, which probably indicates a slightly more luminous sun than ours.

The binary star 70 Ophiuchi has a spectrum intermediate between the second and third types (K, Pickering), probably indicating a rather fainter body than our sun. An orbit computed by Dr. See, combined with a parallax of 0.16 sec., found by Schur, gives a combined mass of 2.94 times the sun's mass. This parallax would reduce the sun to a star of about 4.05 magnitude, and as the photometric magnitude of 70 Ophiuchi is 4.07, the star is about equal to the sun in brightness. But as the star's mass is 2.94 times the sun's mass, the star should be, if exactly comparable with the sun, about twice as bright. Hence it would follow that the surface luminosity of the star is less than that of the sun—about one-half; and the spectrum indicates that this is probably the case.

Let us now consider the case of the "Algol variables." For Algol itself, Vogel found from spectroscopic observations the diameter of the bright star to be 1,074,000 miles, with a mass of 4·9 of the sun's mass, and for the "dark" companion a diameter of 840,600 miles and a mass of 2·9 of the solar mass. This result was obtained on the assumption that both components are of equal density—about one-third that of water. But that a dark body of such large size should have the same density as a bright body, like Algol itself, seems highly improbable. The density of the planet Jupiter—which has some inherent heat of its own—is about 1.30, and that of Saturn about 0.68. We should, therefore, expect that a large body, like the companion of Algol, would have a considerable amount of inherent light, or surface luminosity. Let us see what brightness it *could* have without sensibly affecting the observed light variation of Algol. That is, what is the maximum brightness which the companion might have without producing a secondary minimum of light when hidden behind the disk of the bright star? Chandler finds for Algol a parallax of 0.07 sec. The sun placed at the distance indicated by this small parallax would be reduced to the light of a star of 5.84 magnitude, and the photometric magnitude of Algol being 2.31, it would be 3.53 magnitude, or nearly 26 times brighter than the sun. Let us assume that the companion has this magnitude of 5.84—which it might have without the spectroscope showing it. Then when in the course of its orbital revolution round Algol it is hidden behind the bright star, the normal light of Algol would be reduced by its 27th part. This means that the light of Algol would be diminished by about 0.04 magnitude, or from 2.31 to 2.35, a difference which would not be perceptible to the naked eye, and could hardly be detected with certainty by even the most delicate photometer. The spectrum of Algol is, according to Pickering, B 8 A, that of Sirius being A. Comparing the two stars, and assuming the surface luminosity to be the same, I find a parallax of 0.11 sec. for Algol. This would reduce the sun to a star of 4.84 magnitude, and if we suppose the companion to have this brightness,* then Algol would be about 10 times brighter than its companion, and when the latter is hidden behind the brighter star, the light of Algol would be reduced from about 2.31 to 2.41, and even this difference could hardly be determined with certainty. It would seem probable, therefore, that the companion of Algol has some inherent light of its own, and is not quite a "dark body." Assuming a parallax of 0.07 sec., I find that the surface luminosity of Algol itself would be 17 times that of the sun.

In the Algol system the components are separated by a distance of over two millions of miles (between their surfaces), but in some of the "Algol variables" the components revolve in contact, or nearly so. Some have both components bright. Examples of this type of variation are β Lyræ, U Pegasi, V Puppis, X Carinæ, and RR Centauri. The characteristics of the light fluctuations are, according to Dr. A. W. Roberts,† as follows: (1) "continuous variation, indicating that the component stars are in contact," and (2) two maxima and two minima, showing that the components are both bright bodies. The variation of β Lyræ is well known. It is not usually considered as an Algol variable, but it now seems probable that it should be included in that class. Myers finds that β Lyræ probably consists of two ellipsoidal components revolving nearly in contact, the mass of the larger component being 21 times the mass of the sun, and that of the smaller 9½ times the sun's mass. He thinks that the mean density of

* Knowledge and Scientific News.

* Astrophysical Journal, June, 1905.

* It has been recently found that a difference in brightness of two magnitudes between the components of a spectroscopic binary is sufficient to obliterate the spectrum of the fainter component.

† Monthly Notices, R. A. S., June, 1903.

the system "is comparable with atmospheric density"—that is, that they are "in a nebulous condition." If this conclusion is correct their diameters must be enormous. Taking the density of atmospheric air as 814 times less than that of water, I find that the larger component would have a diameter of about 25 millions of miles, and the smaller about 19 millions. The parallax of β Lyræ has not been ascertained, but supposing it to be about one-hundredth of a second, the sun would be reduced to a star of about the 10th magnitude. The maximum brightness of the star is about 3.5 magnitude. It would, therefore, be—with the assumed parallax—6½ magnitudes, or about 400 times brighter than the sun. From the diameters found above, the combined surfaces of the two components would be 1,332 times the sun's surface. Hence their surface luminosity would be less than one-third of that of the sun. This would agree with Homer Lane's law, by which a gaseous body gains in heat as it consolidates, and β Lyræ is probably in a very early stage of stellar evolution. If the parallax is larger than assumed above, the surface luminosity would be still less.

Another remarkable star is the Southern Algol variable V Puppis (Lacaille 3105). Both components are bright. The spectrum of the brighter component is, according to Pickering, of the "Orion type," B 1 A, and that of the fainter B 3 A. The period of light variation is 1.454 day. The spectroscopic measures show that the relative velocity is about 380 miles a second. The combined mass of the system is, therefore, about 70 times the sun's mass. As the star is variable in light, the plane of the orbit must necessarily pass through the earth, and the accuracy of this result for the mass is, therefore, certain. This great mass, and the star's magnitude, about 4.50, show that it must be at an enormous distance from the earth. According to Dr. A. W. Roberts, the density of the components cannot exceed 0.02 of the sun's density, and he finds that they "revolve round one another in *actual contact*." Assuming this density and a mass of 35 times the sun's mass for each component, I find that the diameter of each would be about 10½ millions of miles. Now, comparing it with Algol, of which the diameter and mass are known, and assuming the same surface luminosity, I find that the parallax of V Puppis would be about 0.0018 sec., or a light journey of about 1,800 years. As it lies in or near the Milky Way, it may possibly be one of the larger stars of the Galaxy. The parallax found above would indicate that the star is about 5,000 times brighter than our sun would be if placed at the same distance. The star is thus a very remarkable and interesting object. Its mass is very large, its density is very small, and the intrinsic luminosity of its surface is very high. Its distance from the earth is very great. Its orbital revolution is very rapid, and the variation of light is small and very regular. It is, in fact, one of the most remarkable objects in the heavens.

STUDY OF LUNAR PHOTOGRAPHS.

By the Paris Correspondent of the SCIENTIFIC AMERICAN.

MESSRS. LOEWY AND PUISEUX, of the Paris Observatory, have been engaged for some years past in making a photographic study of the moon, and the remarkable series of plates which they are obtaining go to make up the Lunar Atlas. The latter promises to be a most valuable aid in future investigations upon this subject, and in fact the observers have already been led to form a theory as to the two following questions, namely, in what manner a planet is made to pass from the liquid to the solid state, and again, at what point in this transformation have the earth and the moon already arrived. The *ensemble* of the topographical data obtained in the course of their investigations, and especially some of the recent photographs, seem to throw considerable light upon these questions.

The answer to the first question seems to depend upon the solution which is adopted for the second. Thus some authorities consider the solidification of the earth as nearly finished. The volcanic phenomena only show the existence of isolated liquid parts which are insignificant when compared to the total volume. In this system, the solidification commenced at the center and has been propagated to the surface. Those who uphold this theory base their claims upon the authority of Lord Kelvin, G. H. Darwin, King, and others. The greater number of geologists, on the contrary, with Prof. Suess and M. Lapparent, admit the existence of a lithosphere or relatively thin shell which envelops an incandescent mass. Here the solidification commenced at the surface, and progressed slowly toward the center, opposing an increasing obstacle to volcanic eruptions, the latter being still possible, however, in the case of the earth. If instead of starting from the actual state of affairs we attempt to present the facts in historic order, the two schools are in accord as to placing a totally fluid state at the origin, conforming to the ideas of Descartes and Laplace. The passage from the liquid to the solid state is carried out by small portions under the influence of the surface cooling. What becomes of the scoriæ which are thus formed? Here the divergence commences. The partisans of the solid core argue that the greater number of mineral substances contract in solidifying, inversely to what takes place in the case of water. The solid parts will not, therefore, float like ice but plunge into the interior, where they will pass again into the liquid state under the influence of a higher temperature. This movement tends to make the temperature uniform throughout the entire mass. Besides, the high pressure which prevails in the interior succeeds in keeping in the solid state the substances which dilate in melting. The depth which the scoriæ can reach goes on increasing with the time. They finish by reaching the center, taking the place of the lighter bodies, which are pushed to the surface. Their agglomeration forms a solid nucleus which extends by degrees until it includes the whole planet, leaving some pockets which are formed of the more fusible substances.

To this theory the partisans of the lithosphere reply in pointing out the existence of mineral substances which expand in solidifying, like water. We have thus at least one class of scoriæ which is destined to float and continually increase, forming the first solid crust. There remain the bodies of the second class, those which contract and pass downward in solidifying. But these bodies cannot reach the center, for they soon meet with denser layers which have been already kept at a lower level by hydrostatic equilibrium. This new class of scoriæ can only move through a short distance from the surface, and finally becomes amalgamated with the first. As soon as the first crust which is thus formed becomes capable of opposing an obstacle to the superficial outbursts, the cooling is retarded in an enormous proportion. Henceforth the upper layers of the internal fluid only solidify with extreme slowness. The extent and frequence of volcanic phenomena, the universal and regular rise of temperature in penetrating into the soil, show at present a figure near 30 miles for the mean thickness of the solid crust. These facts are certainly more difficult to interpret in the case of the theory of the solid crust. The same applies to other general and well-known phenomena, for instance: (*a*) The presence, even up to the surface, of material of greatly varying density including metals which are much heavier than the average of the globe. If the phenomena took place in the order indicated by Lord Kelvin, these metals should have been imprisoned in the solid nucleus from an early period without any possibility of coming to light. (*b*) The general tendency toward isostasis, that is, the existence of density variations which compensate the inequalities of the soil as to the force of gravity, and render hydrostatic equilibrium possible at a certain depth. This compensation seems obligatory if the earth's crust is floating, but as superfluous if the entire mass of the globe is solid. (*c*) The great difference of level which we observe at the surface of some of the planets. It is the opinion that these differences have been produced by the action of a liquid interior upon a thin crust of irregular density. It seems, on the contrary, that if the solidification took place, starting from the center, coming finally to the surface layer, we should see a greater balance on the surface. Upon the moon we cannot tell whether there is an increase of temperature with the depth, or a variation in the force of gravity, but we can point out some particularities upon the lunar photographs which show that the solidification takes place starting from the surface.

Thus the differences of level are relatively greater and more abrupt upon the moon, and moreover they show in different forms the dynamic effects which a liquid in movement should exert upon the solid walls which contain it. These effects are in the first place the surface outbursts which have invaded two-fifths of the visible surface, transforming them into level plains which show numerous vestiges of the former relief on the periphery. Again we find numerous traces of instability of mountainous masses in the vertical direction on the moon, such as the linear cassures which circumscribe the Hoemus Mountains, the Apennines, and the Caucasus, the well defined terraces of the Wall and Theophilus, as well as the marginal fissures of Sabina and Hesiod. The proximity of a powerful liquid areas at a time. This cause may account for the displacement of masses in the horizontal sense, over large areas at a time. This cause may account for the dismantling of the Apennines' crest, the disjunction of cubical blocks from the Caucasus, and the forming of the straight valleys of Rheita, the Alps, and Ariadoeus. The most conclusive argument in favor of the hypothesis of a gradual cooling from outside to inside is given by the following facts, which the study of the photograph renders evident in a marked degree. An attentive analysis of the widely varied formations which cover the lunar surface allows of admitting that after the formation of the first thin envelope of the lithosphere, the retreat of the liquid mass took place progressively, and a moment necessarily comes where it partly loses its contact with the solidified part; it is thus separated from it by a short interval which gives space enough for the oscillation of the tides in the liquid. As in the case of the earth, when at a certain period and for unknown reasons the eruptive forces became especially violent, the solid crust yielded to the exceptional pressures in its less-resisting elements, and the interior liquid overflowed it. These local uprisings thus gave rise to the great circles and other formations in the polar regions, where the cooling was much more rapid and where the crust took a greater thickness for reasons which are easily understood. But in the equatorial zone, where the tides and the centrifugal force are greatest, these violent disturbances led to great cataclysms which constitute the seas. The existence of traces of the former relief which are still visible on the borders thus shows us the nature of these powerful evolutions. Thus each eruptive movement indicates, by the plane and even surface of the formations, the level of the subjacent fluid.

This process, as can be observed, is repeated several times, and will no doubt be repeated afterward with a continually decreasing energy until the moment arrives when the envelope has become such that it opposes an invincible obstacle to the eruptive actions. The lunar photographs show in a conclusive manner five successive stages in the retreat of the matter in fusion. This progress is also shown by the interior terraces of Maurolycus and Boussingault, and by the parasitic circles which are formed at the expense of Albategnius and Clavius. We observe it also at the periphery of nearly all the seas where we have the juxtaposition of the primitive plateau and the lower layer. But the most striking example is perhaps given by the concentric bands which surround the Nectar Sea. Here we recognize, from the plateaus of the north elevation down to the bottom of the lower circles, five levels, or stories well defined, and separated from each other by several thousand meters, corresponding to different epochs. We thus observe the progressive contraction of the internal fluid and its solidification starting from the surface. The observed result would be quite different if the solidifying had started from the center and finished at the surface. Only the final level would be apparent, and the manifestation of eruptive forces would not have had the opportunity of being produced, nor the means of leaving permanent traces at widely different levels. To this *ensemble* of facts only two arguments can be opposed in favor of the existence of a solid crust. These arguments are of rather a mathematical order, and their concrete value may be contested.

The first is taken from the theory of tides. Lord Kelvin finds by calculation that a thin and impenetrable crust, even though as rigid as we may allow it, is obliged to share in the periodic deformations caused in the internal fluid by the planetary attractions. Henceforth the oceanic tides would no longer be manifest. The existence of these tides therefore excludes the idea of an internal liquid. Another objection raised by Mr. G. H. Darwin is based on the existence of important inequalities in the earth's relief. Calculation shows that a single and uniform crust, supposed to be less rigid than steel, and thinner than one-fifth the radius, ought to bend under the additional load of the mountainous masses, and it seems that this consequence applies *a fortiori* to the moon, which is more irregular than the earth on the surface. The reason brought out by Lord Kelvin relates more especially to the earth, where the sea's tides can be observed. Even in this case it has no value unless the following two questions are answered in the affirmative: 1. Whether the tides of the internal fluid have an amplitude comparable to that of the sea's tides. 2. Supposing that these tides are produced, is it certain that they would alter the configuration of the crust? The reply to the first question should already be regarded as doubtful, since the coefficient of viscosity, or of internal friction, is an essential element in the amplitude of the tides. Experiment alone could show if the manner in which this coefficient is introduced in the calculation is conformed to the reality. Everyone knows that the sea's flux usually undergoes a retardation of several hours from the passage of the moon on the meridian.

It is clear, on the other hand, that the internal matter, submitted to enormous pressure, should offer a greater viscosity than sea water, and obey the planetary actions more slowly. As the latter change in direction in a few hours on account of the daily movement, it is quite possible that their effects do not accumulate, and are not made evident by any appreciable flux. It may be argued that in the case of the moon, the tides of terrestrial origin must have had a long period, and a great amplitude at a remote epoch. It seems certain that their action must have brought about a considerable delay in the appearance of a coherent envelope. Under the influence of these powerful waves, the crust had to undergo violent alterations at first, giving passage to the internal fluid, but nevertheless it finally took a great thickness from the continual influence of cooling and contraction of the surface layers.

This idea is confirmed by the abundance of the surface overflows of which the moon shows the traces in all its equatorial region, which is precisely that which is the most subject to tides. Again, the existence of very different and well-defined levels shows that the crust, in becoming more resistant, acquired a certain degree of independence relative to the internal fluid. It took its fixed form, leaving the required amount of play for the movements of the internal liquid, as we have before indicated. The interval which was temporarily formed was occupied by a cushion of gas at a high pressure, which was elastic enough to prevent any sinking, and of too small a mass to interfere with the isostatic compensation. The internal tides could thus be produced without endangering the external surface. The second difficulty, which is suggested by considering the mountainous masses, does not exist in the same degree for the moon, where gravity is six times less than on the earth. But, in fact, we need not consider it, either for the earth or the moon, since it comes from a doubtful theory resting entirely on the inexact hypothesis of uniform composition. Seeing that the distribution of materials in the lower layers is sufficient for diminishing the calculated effects of gravity, it should also suffice to distribute the stresses in a sense which is favorable to keeping the relief of the surface. The mountainous excrescences contribute to the general balance, instead of compromising it. They are not only supported by the tenacity of the neighboring parts but it is probable, as Airy suggested, that they possess roots which plunge into a denser medium, and thus are kept upheld or afloat.

It seems, in consequence, that the study of the moon should confirm geologists in their preference for the thin layer theory, and convince them that the passage to the solid state, which is still unfinished for the moon, is very far from the end in the case of the earth.

MUSICAL INSTRUMENTS: THEIR CONSTRUCTION AND CAPABILITIES.—III.*

By A. J. HIPKINS, F.S.A.

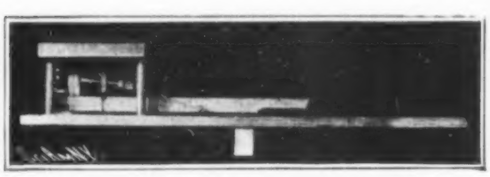
HAVING described in the previous papers those musical instruments (whether string, pipe, or reed) which belong to such combinations as the orchestra and military band, we will now consider those furnished with keyboards, by which they are manipulated; and, as this contrivance originates a fresh order of

GLOCKENSPIEL, WITH A COMPASS OF TWO OCTAVES.

A small case containing twenty-five hemispherical gongs which, on pressing the keys, are struck by little hammers.

treatment, I have decided to group keyboard instruments as a separate class. Without the keyboard, music, in its modern European development, would hardly have been known, the orchestra might not have progressed beyond the Hungarian gypsy band, and there would have been no organ to aid religious service, or support choral masses in harmony; and the facilities for the composer the pianoforte offers would have been wanting. Indeed, there can be no doubt that the keyboard, by the privilege it gives for the trial of several voices or parts, has helped to build up counterpoint, and, ultimately, harmony.

Before proceeding to the various instruments that



MODEL OF ACTION, NUREMBERG PIANO.

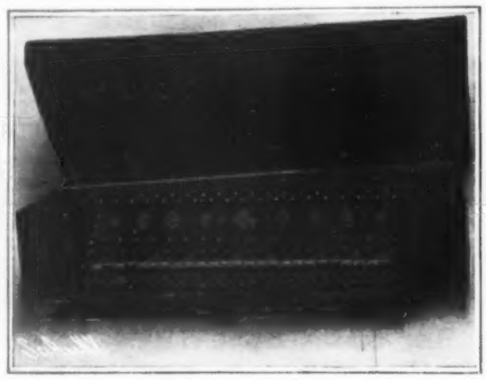
Primitive Viennese method without escapement.

are accessible, by the keyboard, to full harmony in any combination of notes, it will be well to consider the keyboard alone, and to try to make out its history. Like all inventions that have required time for their recognition, and an ever-widening use to bring out their importance, the record is imperfect, and the materials fragmentary, that can throw light upon its development. Its origin was either in the organ, when an aggregate of pitch pipes only, or in connection with the monochord, the normal mediæval pitch measure. It is accepted that organs, hydraulic or otherwise, ex-

AN OLD GERMAN BOOK ORGAN IN THE FORM OF A PARCHMENT-COVERED BOOK.

The keyboard and blowing apparatus consists of a small bellows and a reservoir. Beneath the keyboard and the bellows are the stopped wooden pipes.

isted in the time of the Roman domination, and may have been of Greek invention. In the eighth and ninth centuries organs were heard of in England, France, and Germany; but up to the eleventh century, there appears to have been no use made of balanced levers or keys to produce the notes. Sliding rods, like modern drawstops, seem, from the imperfect notices existing, to have been the only means for obtaining and controlling sound from the pipes. As single notes only were practicable, there could have been no harmony whatever, unless two persons, drawing out slides

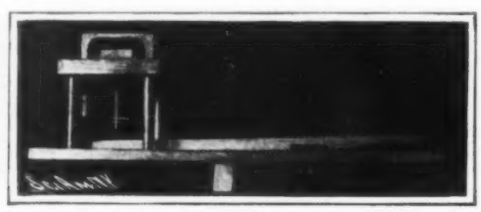


SPINET OR VIRGINAL.

Inscribed "Franciscus Bonafinis 1585," also "after a lapse of 132 years, repaired by me N. N. the year 1717."

simultaneously, could have set two notes going. There are three ways open to us to trace historically the construction and improvement of musical instruments, or whatever appertains to them.

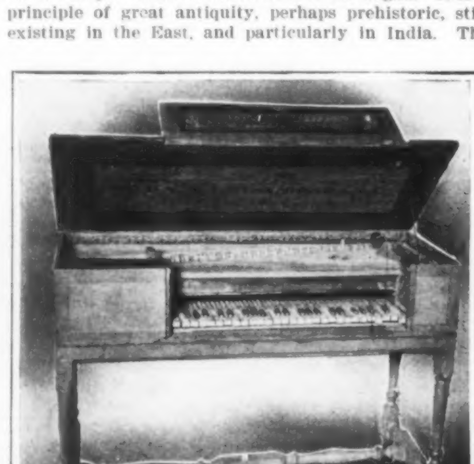
The sure one is the examination and comparison of existing instruments; the next is found in graphic representations, to be valued according to the realistic or conventional treatment the draftsman may employ. The last and least satisfactory is that of written description, the difficulties of which are made more perplexing by the confusion attending names used by writers in different places and at different times. With



MODEL OF SPINET ACTION SHOWING THE QUILLED JACK ON KEY.

the early keyboard we are only left with such indications as we can get from pictorial or written evidence, as no known keyboard is older than the end of the fifteenth century. At this point of our inquiry we ought not to overlook the keys of the hurdy-gurdy or vielle, the viol sounded by a wheel instead of a bow. The fact of this instrument having strings tuned as drones puts back its origin to when the drone was the only addition to melody.

The bagpipe was the wind instrument similarly burdened, and there is every reason to believe that the drone early became characteristic of the organ. It is a principle of great antiquity, perhaps prehistoric, still existing in the East, and particularly in India. The

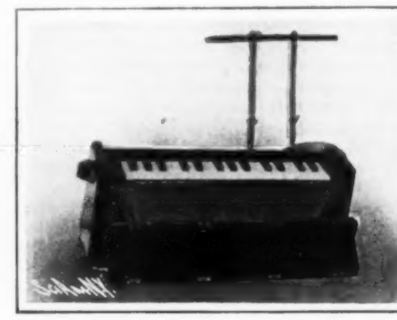


SPINET OR VIRGINAL MADE IN FLANDERS, 1600, BY CRISTOFEL RUCKERS.

Only two specimens of Ruckers spinets are known.

keys of the hurdy-gurdy are simply slides pushed back by the player, with projections to stop the strings and produce notes according to the vibrating length required; and as the instrument is held with the keys downward, these slides when released fall back by their own weight. It is possible that the hurdy-gurdy keys suggested the contrivance of balanced levers for stopping the monochord, and thus the clavichord, a complex of monochords, for at first the strings of it were of equal length, came about; but it is equally possible that the invention of balanced lever keys was earliest applied to the organ. We have to step with great care in this inquiry.

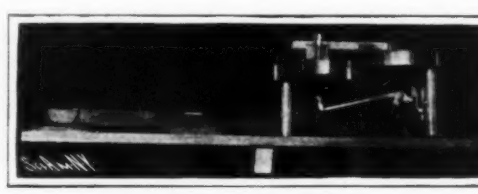
Of what happened, if anything, in the eleventh and twelfth centuries concerning keyboards, we know nothing. The first glimmering of light is in the thirteenth century. At that epoch a small portable organ for processional use, a shrill pitch giver and little



PORTABLE MELODEON.

At the back a single bellows; in the front an air-reservoir. A double set of free reeds in unison. The instrument is contained in a small red mahogany case with a leather carrying strap.

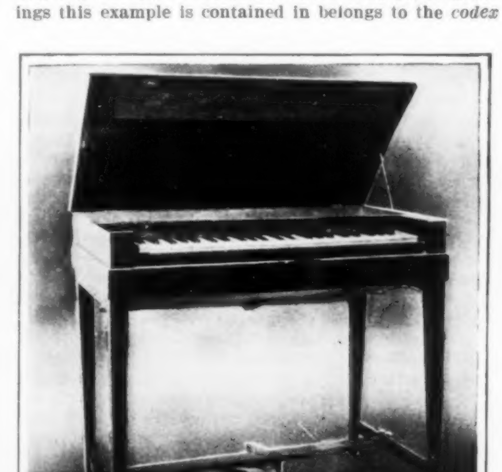
more, had been invented. One of the valuable results of the music division of the inventions exhibition of 1885 was the publication of important books concerning music and musical instruments, two of which were undertaken by Mr. Quaritch. The one I now particularly refer to is entitled "Notes on Early Spanish Music," with illustrations of thirteenth and fourteenth century instruments. The author is Don Juan Riaño, who was the special commissioner appointed for Spain, in connection with the music loan collection attached to that exhibition.



MODEL OF ACTION.

Piano by Vatter: Viennese method; hammer in pin and on key. Perfect escapement.

In Don Riaño's book there is a drawing, copied from an authenticated manuscript of the thirteenth century, in which a portable organ, or *portatif*, appears. It has nine pipes, but it has been sufficient to the artist to figure three keys, which are hardly keys, in the sense of levers, but evidently represent those gimlet-looking finger stops of which I shall give other instances. When depressed by the fingers they lowered, by some internal contrivance, the valves or pallets necessary to admit wind to the pipes they served. There is no clew to the actual notes. The set of drawings this example is contained in belongs to the *codex*



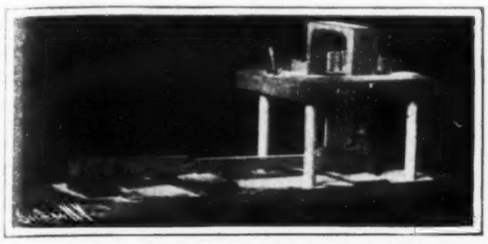
SERAPHINE MADE IN UNITED STATES IN 1840.

The seraphine was invented in 1833 and was the precursor of the harmonium.

of the "Cantigas de Santa Maria," of which there are three manuscripts: one in the National Library, Madrid, and two in the library of the Escorial. The Spanish Royal Academy have published this work; but these interesting and important musical miniatures had already appeared in "Instrumentaria Española," by Don Francisco Aznar, Madrid, 1880.

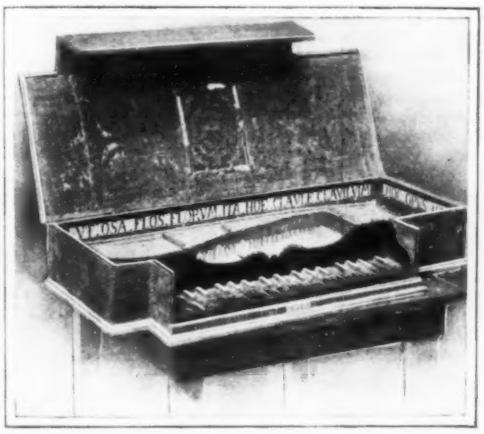
* The illustrations of these articles depict instruments in the admirable collection of Mrs. Crosby Brown in the Metropolitan Museum of Art, New York city.

I will defer the next illustration from Don Riaño's book, in order to continue with these finger stops, which evidently remained in use in portable organs after balanced keys had been employed. An instance of them may be seen in the National Gallery, in an altar piece by Orcagna, the date of which is given in the catalogue as A. D. 1357. The order of these stops is not clear, but seems to be chromatic, and the sharps



MODEL OF HARPSICHORD ACTION. KEY WITH QUILLED JACK.

are of the same color as the naturals, not contrasted as afterward became the custom. Another instance of such an instrument is found in a beautiful female figure, representing Music, depicted in a fresco, attributed to Taddeo Gaddi, and preserved in the Spanish chapel of Santa Maria Novella, Florence. She is represented as singing, while touching with her third finger one of these stops. There are two rows of stops, as in Orcagna's altar piece; and that the back and upper one is chromatic, I entertain no doubt. It is true that the back row appears to have as many stops as the front one, as may be seen in Mr. Timothy Cole's woodcut of



CLAVICHORD MADE IN ITALY IN 1537 BY TRASONTINUS.

the figure in the Century Magazine, March, 1889. This artist has favored me with a photograph of the painting, to prove the accuracy of his engraving, so it may be assumed either that Taddeo Gaddi has not cared to be exact or that some of the finger stops were dummies.

Fifteenth century illustrations of similar stops may be seen in *portatifs*, depicted by Memling in paintings preserved in the hospital of St. John at Bruges. The accuracy of these delineations is unquestionable, as is also the complete chromatic order of the stops. One of these representations of a *portatif* is in a painting in the famous shrine of St. Ursula; the other and

OCTAVE SPINET HAVING COMPASS OF TWO OCTAVES AND A FOURTH.

Quill plectra. Made in Italy in the 17th century. These small spinets were tuned an octave above the ordinary pitch and were sometimes included in a larger instrument.

larger in the "Marriage of St. Catherine." The latter is dated 1479, but the instruments represented may have been already old when the painter selected them for delineation. I now return to Don Riaño's next illustration of a *portatif*, which is different. It is copied from a fresco, an altar piece in the Cistercian Monastery of Nuestra Señora de Piedra, Aragon, and is dated 1390. Here is shown a *portatif* with three rows of pipes and balanced white natural keys, with one square chromatic key let in. Assuming that the treble of the instrument terminates at A, which occurs in fifteenth century positive organs, and recognizing the necessity in the plain song of a B flat for transposition, we cannot be wrong in regarding this square key as that note. If there is another B flat an octave lower, which according to Guido's scale was likely to be the case, the

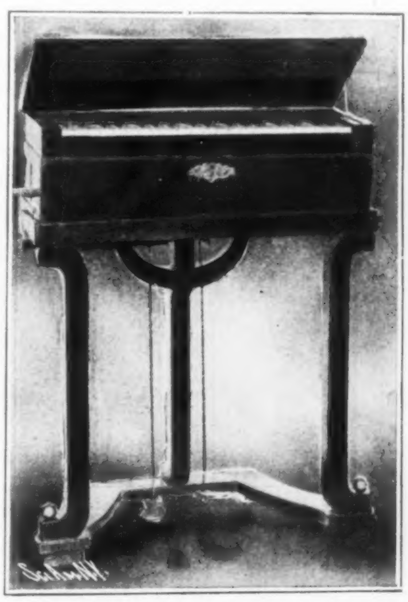
MODEL OF CLAVICYTHERIUM ACTION.

Quilled jack on key, showing mechanism for upright form of harpsichord.

hand of the player covers it. Virdung, in 1511, figures a diatonic keyboard with two B flats, but this drawing is not altogether to be relied upon as an exact representation. There were such keyboards no doubt, only of an older fashion. Fra Angelico, who was painting in the first half of the fifteenth century, represents *portatifs* with diatonic keyboards, and, in one important instance, a dubious indication of incidental upper keys. I think, however, it is proved that full chromatic keyboards were in contemporary use with diatonic ones, including B flat, which was reckoned a diatonic note in the fourteenth and fifteenth centuries.

With regard to the keyboards of large church organs I cannot do better than briefly summarize the information on them, supplied by Prætorius in the second volume, "De Organographia," of his great work entitled "Syntagma Musicum," and published at Wolffenbuttel, A. D. 1618; it was completed by the Theatrum Instrumentorum seu Sciagraphia, that is to say, the illustrative plates, A. D. 1620.

I will pass by what he says about the earliest organs in churches, because he is not speaking from personal knowledge, to start with the famous Halberstadt organ, with which he was familiar. This organ was built, according to inscriptions upon it, in A. D. 1361, and renovated in A. D. 1495. Whatever happened in this renovation we shall find that the manual keyboards and compass of keys were undisturbed, and that prob-



A MELODEON MADE IN EARLY PART OF NINETEENTH CENTURY.

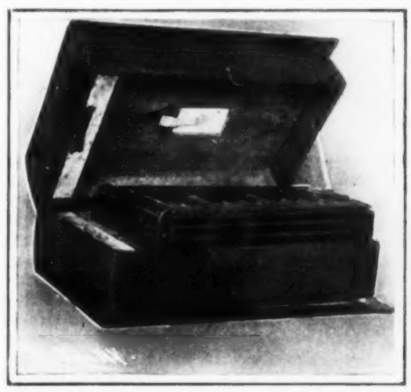
Compass three octaves and two notes. One pedal works a bellows, the other a small swell shutter.

ably the pedal keyboard was original, but as to this doubt may be allowed. The compass of the two highest keyboards was the same, and exactly that of the ancient Greek scale of fourteen natural notes, extending from B natural in the bass clef, "hypate hypaton," to A in the treble clef, "nete hyperbolæon." Thus proving that the church organ keyboard was a scholastic conception in the first instance, and we shall find it, although afterward only partially, for some time adhered to, and with Pythagorean, which was a nonharmonic tuning. The fifteenth natural key in that conception was the B flat near middle C, which belonged to the conjunct tetrachord, "trite synnemenon." But the necessities of the transposition of the plain song to accommodate voices, for which we have the authority of Arnold Schlick, who published his book in the same year as Virdung, A. D. 1511, had

GLASSICHORD.

The hammers strike small plates of glass arranged in two rows.

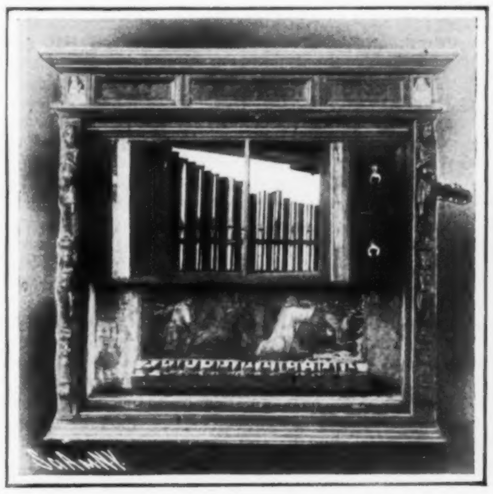
brought about the intercalation of the chromatic keys or "ficti" as they were then called—feigned notes—and consequently the restricted compass of the Halberstadt organ was, I have no doubt about it, originally chromatic. The lowest manual was a bass keyboard from an approximately 32-foot B natural to 16-foot C.



BIBLE REGAL.

An oak case in book form placed at the back of the keyboard contains two bellows, which are lifted alternately, supplying wind to the instrument. Immediately behind the keyboard is a set of pipes, furnished with beating reeds placed on their sides. The keyboard folds in the middle, and with the pipes can be placed within the book-shaped case. Hence the name book or bible organ.

The highest but was for the mixture, various pipes of different but related pitches sounding together when a key was put down, without any attempt to sort them into various registers. In fact, the first essay in this direction is here seen, in the speaking pipes in the



A SEVENTEENTH CENTURY GERMAN CABINET ORGAN.

Ebony keys with white sharps. The organ is blown by a carved lever which projects from the right-hand side of the cabinet. The air reservoir (now missing) was originally placed on top of the cabinet.

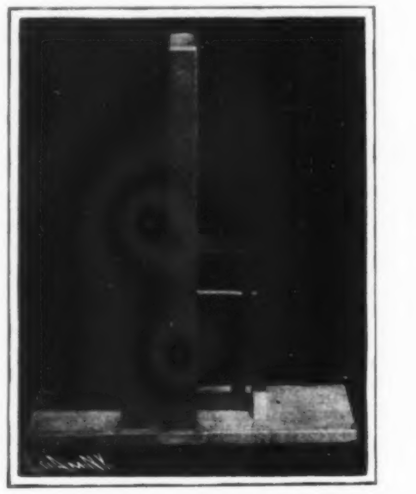
front of the organ, the "principal," as it was called, being on the second or intermediate keyboard apart from the mixture, and on the third or bass manual connected with the large, deep bass pipes in the side towers. This principal was a four-foot stop, the measure of an English principal of the present day, and it is curious that this old German tradition has really been maintained in England while it has not in Ger-

many, where the eight-foot foundation register is now the principal. We call the eight-foot foundation stops diapasons—that is to say octaves below our principal, diapason being the Greek equivalent for octave. I can hardly accept the explanation which derives this name from an organ builder's rule, inasmuch as though called diapason his rule would serve to measure any pipe in any register. I believe the deep third keyboard pipes were originally used for drones, and to keep such notes continuously sounding was how pedals first came into use. We call a drone now a pedal point, and composers use it, especially for the tonic or dominant, with great effect. The Halberstadt pedals were for bass notes to the mixture, and were mixture notes themselves, although without the highest rows of pipes. We may consider the pipes in the side towers were also upon the pedals, but as to this the text is not clear. If the usually received statement that pedals were invented by Bernhard, organist to the Doge of Venice, in 1470, be true, then the Halberstadt pedals were no older than the renovation; but I think we may safely follow the suggestion of Prætorius that pedals had been long in use in Germany, and were only introduced by Bernhard at that date into Italy. They were not generally adopted in other parts of Italy, or in England either, until the present century. The compass of the Halberstadt pedals was only an octave: B natural, C, C sharp, D, D sharp, E, F, F sharp, G, G sharp, A, and B flat. We learn from Schlick that B flat had been the highest pedal key, and some inconvenience had been caused to organists by changing this note to B natural.

Now, the Halberstadt keys were very wide, on the two upper keyboards four inches from center to center of each key, with chromatic keys two inches wide, placed two and a half inches above the diatonic. The keys of the two discant manuals were rounded, but in the bass keyboard they were square. I am indebted to Dr. Hopkins for these measurements, which are given in his valuable article upon the organ in Sir George Grove's dictionary, and, I presume, are founded upon Prætorius' text and drawings. There could be, with this keyboard, no question of stretching an octave with the extended hands, or even more than a major third, and what we call fingering was entirely out of the question. The organist used the side of his clenched hand to depress the keys.

I will now briefly show, from Prætorius, the gradual upward extension of compass; but, for a long while, the B natural in the bass clef remained the starting note, according, as I have said, to the old Greek scale. It would appear that the pitch of the renovated Halberstadt organ was about a tone above our medium pitch of C, 528 double variations a second; but the pre-Reformation B natural was a fourth higher than this Halberstadt pitch, as was the case in the old Magdeburg organ, which was still remaining in Prætorius' time. We have seen that the Halberstadt organ had no higher key than the old Greek A in the treble clef. Prætorius describes the keyboard of the church organ of St. Egidius, at Brunswick, the date of which was A. D. 1456, as permitting the stretch of a fifth, instead of a major third, as at Halberstadt. He gives a drawing but, unfortunately, not the compass of the Brunswick keyboard; but he does of another organ of the same period, that of St. Salvator, at Vienna. In this the manual compass extended to C in the treble clef; the pedals as at Halberstadt. An undated organ at Minden, with keys 2½ inches wide, according to Prætorius's own measurement, had the same compass, pedal and manual as this Venetian organ. The next quoted by him was the organ of St. Sebald, at Nuremberg. Here the pedals went down to the lower A of the bass clef, the "Greek proslambanomenos," with B flat also added, but the manual kept to the normal B natural, ascending however to treble clef D. Another by the same builder, Heinrich Traxdorff, was in the Church of Our Lady of Nuremberg, without pedals, and only ascending in the manual to the Halberstadt A, but he introduced the octave register in the St. Sebald organ, and presumably in this, in addition to the already separated principal; the mixture remaining as the Hintersatz or Back organ. A further extension was made by Krebs and Mulner in the organ at Mildenberg, where the manual was advanced to the higher F of the treble clef; the lowest bass key still remaining B natural but the pedal starting from A, and from thence to the A above, a chromatic octave. We are now nearing the period of a great change in the organ keyboard, when Conrad Rotenburger built about A. D. 1475 the great organ at Bamberg, with similar compass, but to change it eighteen years later, that is in A. D. 1493, to the "long measure" in the bass, for the pedals, F, G, A, B flat, and then from B natural, chromatically, to the B flat above the bass clef, altogether an octave and a fourth; and for the manuals from the same F below the bass clef to A above the treble, three octaves and a third. The width of the keys was gradually being lessened until, when Cranz, in A. D. 1499, built the great organ of St. Blaise, at Brunswick, the octave was only the width of nine keys of Prætorius's time, when the octave had come to be comfortably grasped, as it has remained ever since, by an average hand. I ought here to state the compass of a modern German organ, and will take that of the great organ of Ulm, built by Walcker of Ludwigsburg, and accounted one of the finest German instruments. The manual keyboards, three in number, go from C below the bass clef to F above the treble, fifty-four notes, and the pedals from the octave lower C to D in the bass clef, twenty-seven notes. Large organs built in this country exceed this compass. Messrs. Hill's Sydney organ has five octaves, from C to C, on all five manuals sixty-one notes, and pedals from C to F, thirty notes.

From the end of the fifteenth century the drone bass notes, as tonics or dominants to an octave system, appear to have got the better of the scholastic tetrachordal idea of the scale. Where the long measure, as it may be called, to the low F was not carried out on the keyboard, it was, in fact, as far as possible by substitution of pipes. The B natural key served no longer for that note, but for the G below it; the C sharp key doing duty for A; and the D sharp, when not retained



MODEL OF CLAVICYTHERIUM ACTION SHOWING QUILLED JACK.

for E flat, for B natural; but as this was hardly a drone note, E flat was often preferred. This was the short measure—for 300 years the well-known "short octave." In Italy the short octave has remained quite up to the present time, but generally with E for the apparently lowest key, which really sounds C, as F sharp sounds D and G sharp E; neither of these chromatics being good drone notes. Long drone pipes may be observed in pictures in which are represented the old portatifs, or processional organs, as in the Orcagna altar piece and the Spanish fourteenth century miniature I have mentioned. I can give many examples. And, in the Cecilia panel by the Van Eycks, painted for the Church of St. Bavon, Ghent, but now at Berlin, a positive or small chapel organ is painted in the most realistic manner, and the lowest note, D, has a special key situated below the keyboard at the left-hand side, while above this key there is a latch, the only possible use for which could have been to fix a drone. Perhaps the deep drones came later into large church organs on account of the greater cost of the deep bass pipes.

It will now be interesting to trace the general history of the organ up to that epoch when it may be regarded as a complete instrument. We learn from Prætorius that the back organ, or huge mixture, as I have said,

CABINET ORGAN WITH REMOVABLE SPINET.

Compass, three octaves and eight notes—C to A. On opening the folding doors a cabinet is disclosed, having 14 drawers and a central cupboard with bronze door-mounts, and a decorative bronze panel representing the Entombment of Christ. Below is the keyboard of the organ. The organ is blown by a handle attached to the side of the stand of the case, and working a small bellows beneath the cabinet, from which the wind is transmitted to a wind reservoir placed on the top. Immediately above the keyboard of the organ is placed in a recess an octave spinet. This instrument may be played either within the cabinet or may be withdrawn for separate use. Germany, 1598. Maker, Laurentius Hauslais. On the jack-rail of the Spinet is the following inscription: "D. G. Quid posible apud Laurentium Hauslais X Toribergensur," i. e., "By the favor of God, see what Lawrence Hauslais of Nuremberg can do."

of many pipes to a key, was about the time of Luther's Reformation and translation of the Bible, dissected by the contrivance of separating rows of pipes of different degrees of pitch, as 16-foot, 8-foot, 6-foot, 4-foot, and so on, into registers by means of slides acted upon by drawstops. About this time, also, pipes, which had all previously been open from the mouth piece to the upper end, were supplemented by certain registers of covered or stopped pipes closed at the upper end, thereby introducing the contrast of a quieter and less penetrating tone quality. These stopped pipes were an octave lower in pitch than open pipes of the same length, from an acoustical reason that a node is formed at the closed end of the pipe, and thus the wave length becomes equivalent to twice the wave length of an open pipe corresponding in length. An important structural change, such as the formation of independent registers, was soon taken advantage of for introducing contrasts of various tone qualities. Improved methods of wind supply, and, as has been explained, an extended manual compass with narrower keys admitting of an octave being grasped, an extended pedal compass and lastly the invention of reed stops, which Prætorius places about A. D. 1530, made the sixteenth century organ complete in all essentials; but to be improved upon, added to, and transformed until, in the present day, it has become a triumph of tone, color, and effective combination, and of mechanical skill, assisted by pneumatics and electricity.

The sketch of a complete organ is as follows: A wind supply, pumped by hand labor, hydraulic power, or gas, the air being compressed, as well as collected, from the bellows, is conveyed to the wind chests, where it remains until liberated for use by the player. The top of the wind chest, upon which the pipes stand, is called a sound board, but has nothing to do with resonance; and the pallets, or valves of the channels of air which lead to the pipes, are closed until acted upon by the key mechanism, which is under the control of the player. The action of a key with the old tracker movement is very simple. When the player puts one down, the other end of the balanced lever raises a sticker, which acts upon mechanism governing what is technically and expressively called a "pull down" attached to the pallet.

Formerly, the weight of a touch, and consequent amount of force required from the player, was in direct proportion to the increase of weight from the accumulation of tracker movements; but by contrivances to equalize wind pressure, and particularly by the pneumatic lever, the invention of the late Mr. Barker, who also invented an electric action, the touch of the organ may be as light, with any number of stops drawn, as that of a piano or harmonium. The pneumatic lever is a small power bellows attached to each key, and supplied with high-pressure wind by the key being put down. The service of this invaluable lever is auxiliary to the finger in raising the action. The pipes are of metal or wood, those of metal being a mixture of tin and lead, and are either flue pipes with mouth pieces or reed pipes in which is inclosed a vibrating tongue of metal. Flue pipes may be, as already mentioned, open or stopped at the upper end. Their length and size varies with the pitch of the note; and their scale and form of air column varies according to the quality of tone required. The air, entering a metal flue pipe from a wind chest, is arrested by a flat piece of metal, called the "languid," and, being diverted by it in its direction, is forced through the mouth between an under and an upper lip, the latter being a fine beveled and indented edge, against which the wind thus directed breaks into a state wherein, according to Mr. Hermann Smith's theory, suction alternates with compression, and that portion which goes into the pipes sets up isochronous vibrations, that, agreeing with the period of vibration of the pipe, make the note, and last as long as the pallet remains open. In a wooden pipe the air is divided by a wooden block, performing the same office as the metal "languid." This is the same in principle as the flute player's *embouchure*. His breath passes from the throat, through the mouth and lips, against a sharp edge, giving access to the air contained in the flute. The effective length of an open pipe is measured from the languid to the upper end of the pipe, and in a stopped pipe from the block to the stopper and back again. In the reed pipe the foot is a metal case called a boot. In the boot is a round piece of metal also called a block, pierced in two places, the larger of which contains the reed, and the smaller the tuning wire which regulates the length of the tongue or reed so as to give the true note. The complete reed is a brass tube, in which there is a narrow opening, covered by a tongue of the same metal, the lower end of which is free to vibrate. Air when admitted to the tube forces the tongue away from the orifice, to which it returns by its own elasticity, and the puffs of air thus ejected establish the note, their rapidity determining its pitch. The length and shape of the tube affect the tone quality. As the tongue when at rest covers the opening, unlike that of the harmonium, which is free of such contact, it is known as a beating or striking reed. By the operation of slides which exclude or admit air to whole rows of pipes are formed the registers or varieties of pitch, power, and tone quality, governed by the draw stops. Each of these is really a separate instrument, but bands of them, so to speak, which have certain affinities, are grouped into departments, under control of separate keyboards, called the great, choir, swell, solo, and pedal organs. Not all necessarily in one instrument, especially the solo. Mechanical couplers and composition pedals, the latter the invention of the late Mr. Bishop, assist the player in his combinations. In adapting the pneumatic principle to these mechanical arrangements Mr. Henry Willis has done very much to facilitate performance upon large organs. The great organ has the typical pipes of the organ, the diapasons, and in England, before pedal organs were introduced, which was not, as already

said, effectively done until the beginning of the present century, were upon a light wind and of a fine mellow quality. The different balance of power in the modern organ has unfortunately, yet unavoidably, done away with this musical excellence. As well as these foundation stops there are gathered upon the great organ all those stops, flue and reed, that are most brilliant, as well as the mixtures; and also the reed trumpets and clarion, of 16, 8, and 4-foot stops, which have great richness and power.

The choir organ contains stops of lighter character, and carries with it the idea of accompaniment, as the name implies. The swell organ has grown into very great importance on account of the expression gained by its being in a box with Venetian shutters, which when closed materially reduce the tone, and as they open, produce an effective crescendo. The swell organ is entirely of English origin, and the expedient of louvres or Venetian shutters, in use for the last hundred years, is an adaptation of the harpsichord Venetian swell, invented in 1769 by Burkhard Tschudi, the founder of the house of Broadwood. It is now well known in France, and is there called Récit. It is less known in Germany.

The chief advocate for the extended introduction of the swell box in this country is Mr. G. A. Audsley, who has not only urged it on logical grounds in his treatise on "Concert, Church, and Chamber Organs," published in the columns of the English Mechanic (1886-8), and his recent lectures on the "Swell in the Organ," but has practically proved the great advantages to be secured by the multiplication of expressive departments in the organ. About twenty-five years ago he schemed and constructed his own chamber organ, which was, when finished, and still remains, for its size, the most flexible and expressive pipe organ existing. This can easily be understood when it is known that out of its nineteen speaking stops fifteen are rendered expressive by being inclosed in swell boxes. The two expressive divisions of the great organ, on the lower clavier, are inclosed in two independent swell boxes; the only stop here uninclosed being the *principale grande* (open diapason 8-foot). The upper or choir manual being entirely expressive. The range of expressive effects and *nuances* secured by these means is remarkable, while the tone qualities of the stop remain unaffected. Mr. Audsley now advocates inclosing a portion of the pedal organ to make the bass also expressive. Among organ builders of the present time, Mr. Roosevelt, of New York, makes the greatest use of the swell box. For instance, in his organ recently erected in the auditorium at Chicago, he has, out of its eighty-six manual speaking stops, rendered seventy-nine expressive by inclosing them in five separate swell boxes.

The solo organ is quite modern. Its introduction is attributed to the late Cavaillé-Coll, in France, and Mr. Hill, in this country. The intention of the solo organ is to supply certain effective reed stops on exceptionally heavy wind. The pedal organ is the general bass to the whole instrument. In the largest instruments the 16-foot diapason and other stops are doubled by 32-foot open metal and reed stops, and Messrs. Hill & Son, in their great Sydney organ, have actually introduced a 64-foot reed, the harmonics of which blend in the general effect. To complete the pedal organ, softer stops are now required, of which Mr. Casson is the earnest and able advocate. The charm of a soft bass, in these days of mechanical progress and corresponding stress of life, seems to be everywhere disregarded. I cannot but think that the mechanical progress so wonderfully shown in the modern organ has now gone beyond the intrinsic musical value of the instrument, and attention should be given rather to the improvement of voicing and combining allied registers in suitable families, with the general advancement and proportioning of tone quality, so as to secure a real economy of the various departments. With regard to the extraordinary inventions which have attached pneumatic and electric aid to the organ, something I think may still be said for the old tracker action, which does allow a player gifted with a fine sense of touch some personal control, through the pallet, over the tone denied to him when these natural forces intervene. I should say mechanical ingenuity is not exhausted for ameliorating any difficulties presented by the old movement. I admit that the influence of personal touch on the organ is a debatable question; but I am not alone in upholding its possibility, and the occasional revelation of such a power in the player. The incompleteness of this sketch of the organ would, I am afraid, appear impertinent if I could not refer those who desire more information to the admirable articles by Dr. Hopkins, in Sir George Grove's "Dictionary of Music and Musicians," by R. H. M. Bosanquet, in the "Encyclopedia Britannica," and one in Sir John Stainer's and Dr. Barrett's "Dictionary of Musical Terms."

In the seventeenth century, and perhaps the sixteenth, an interesting offshoot of the organ was the regal, a complete reed stop taken from it and used as a separate instrument for accompaniment in convents and elsewhere. These beating reed instruments are now very scarce. I believe I possess the only large regal in this country; it is an almost portable vox humana. The regal might have been regarded as the prototype of the harmonium, had there not been an unbridged gap between the discontinuance of the regal, which became entirely forgotten, and the invention of the harmonium and its congeners, which did not happen until the present century had come in. The principle of the harmonium is the free reed, the opposite to the beating reed of the organ, the regal, or clarionet. The tongue does not touch the frame surrounding it, and the action of the air in the harmonium is to force it away, and in a now favorite variety of that instrument, the American organ, by suction from the opening, to which it returns by its own elasticity, thus setting up, by puffs of air, isochronous vibrations. The inventor of the principle of the harmonium was a Frenchman, Grenié, who, early in the century, contrived a free reed keyboard instrument, and called it *orgue expressif*. The invention was completed in 1840, by the late M. Debain, who introduced air channels, to control tone quality, and gave his instrument the name of harmonium. It had an air reservoir, to insure a uniform wind pressure. M. Alexandre, also of Paris, gave the player the discretion of doing without this reservoir, by letting the wind supply act, by means of an expression stop, directly under the reeds, thereby giving the harmonium a power of expression it had not before. The harmoniums of Mustel, of Paris, are the most expensive and the most admired. The American organ, which acts by wind exhaustion, is said to have emanated from Alexandre's, but was first made popular in America. The tone is softer, and of less characteristic tone quality than that of the harmonium, and the expression stop is wanting.

Mr. Casson informs me that, by a pressure-regulating screw of his invention, he can give the harmonium and American organ an almost indefinite gradation of power, from *pianissimo* to *fortissimo;* and that the valve is so sensitive that a slight trembling of the finger on a key will produce a vibrato. If this is carried out, the harmonium will be much increased in importance as an artistic instrument. In another direction, that of purity of intonation, an harmonium has been invented by a Japanese amateur, Mr. Shohe Tanaka, called by him, from a suggestion of Dr. Hans von Bulow, "Enharmonium," which, by dividing the octave into twenty keys, increased by a single mechanical contrivance giving enharmonic changes, governed by a knee lever to twenty-six notes, obtains with certain scarcely perceptible limitations absolute purity of intervals and chords; and by a transposing movement, effective throughout the range of the whole chromatic octave, all keys with their modulations are played in the C major or A minor position. The value of this instrument, the fingering of which, owing to the transposition, is not difficult, for choral accompaniment is evident. The instrument has really thirty-six distinct vibrations in each octave, of which only twenty-six are utilized in any one position of the transposed keyboard.

Before proceeding to the last instrument of which I have to treat, the pianoforte, it will be interesting to go back to its precursors, the clavichord, spinet, or virginal, and harpsichord. The use that has been made of all these instruments, and their common possession of strings, resonance boards, and keyboards, makes the clavier instruments a group apart, but of the highest importance to the historical development of music. The original member of this group was probably the clavichord, but it is an inference only, from the simplicity of its construction and the certainty that it was based upon the mediæval monochord. The invention is nowhere recorded. The earliest reference that has been met with to a clavier instrument has recently been discovered by Mr. Edmond Vander Straeten, a well-known Belgian musical archæologist. It is to be found in the seventh volume of his great work, "La Musique aux Pays-Bas." It appears that, in A. D. 1387, King John, of Aragon, requested his brother-in-law, Philip the Hardy, to procure for him an instrument which he calls "exaquir"; and in repeating this request the following year, he describes it as "resembling an organ, but mounted with strings." He also asks for a player able to touch both organ and "exaquir." There has been a musical instrument mentioned in the fifteenth century French poetry long waiting for identification—the "echiquier." There can be but little doubt, according to Spanish and French phonology, of the identity of these names. Curiously enough there is a German form, "schachtbret," in some old rules of the Minnesingers, bearing date A. D. 1404. Whether this organ with strings was a virginal or clavichord we cannot say, but the name "echiquier"—"chequers"—may have come from an alternated color of the keys, or perhaps from a pattern upon the case of the instrument, as seen on some old portatifs. Both clavichord and spinet or virginal were known in the fifteenth century, and the latter had certainly, and the clavichord presumably, attained a useful degree of completeness. There is no clavichord so old known to exist, but an Italian trapeze spinet-shaped one was shown in the Paris exhibition of 1889, dated A. D. 1547. This is the earliest I know of. The clavichord came from the monochord by adjusting a keyboard to a set of monochord strings, that is to say, strings of the same length and pitch, like an Æolian harp is made, and stopping them by little brass uprights, a little widened at the top where they came in contact with the strings, these stoppers—which not only excited the sound but acted as bridges—being called tangents. There was only one wooden bridge, that on the narrow soundboard; a strip of cloth interwoven among the strings prevented any jarring on the further side of the tangents, and also damped the strings all along, when the tangents by the return of the keys quitted them. The strings were early attached in pairs, similar to the lute and other stringed instruments. By making the keys twisted, two, three, or even four tangents were made to act on one pair of strings. At the beginning of the eighteenth century the clavichord got its full number of strings, each pair having its own tangent, and this was the clavichord of Bach, a gentle instrument, which best renders the tender sentiment with which much of his keyboard music is charged.

The spinet was the application of the key-board to the mediæval psaltery, a form of dulcimer, but with plectra, not hammers. The oldest known spinet is dated A. D. 1490, and was shown in 1888 at the Bologna exhibition. Existing records show how much this instrument came into favor about that epoch. When, in 1509, the Chevalier Bayard, the famous knight without fear or reproach, was severely wounded at the siege of Brescia, he was carried to the house of a nobleman whose wife and daughter nursed him and entertained him during his convalescence by playing to him upon the lute and *espinette*, as the French call the spinet. The upright spinet was called "clavicytherium." I am of opinion that the beautiful upright spinet Mr. Donaldson owns, obtained from the Correr collection, and shown in the Loan Collection of 1885, although undated, may be as old as the 1490 spinet of Count Manzoni. There is an exact drawing of it by William Gibb, in my "Musical Instruments, Historic, Rare and Unique" (A. & C. Black, 1888). The spinet had one string only to each note, and the sound was excited by a little point of quill projecting at a right angle from a wooden upright placed upon the end of the key and called a jack. This also bore a cloth damper. According to Scaliger, the quilled plectra were introduced in his boyhood. He was born A. D. 1484. Buff leather was introduced in later years, but never superseded the use of crow quills. Perhaps brass wire preceded the quill points, as Mr. Donaldson's upright spinet certainly had such plectra. After the sixteenth century the musical value of the spinet hardly increased, but it gained somewhat in power, and was a brilliant instrument compared with the clavichord. Extended lengthways into the grand piano shape, and with two, three, and sometimes four strings to a note, generally with one string an octave higher in pitch, more rarely one an octave lower or bourdon, the spinet thus multiplied early became the more powerful and important harpsichord. Double keyboards and stops for registers showed its affinity, at least in idea, to the organ. The harpsichord certainly existed in the sixteenth century; there is one in South Kensington Museum, dated A. D. 1521; it died out with the spinet and clavichord in the last quarter of the eighteenth, unable to maintain the struggle for existence against the piano. Perhaps the last harpsichord was one bearing Clementi's name, dated 1802, which was also shown at the Bologna exhibition. Beethoven's "Moonlight" sonata was published in 1802 for harpsichord or piano-forte, and there is a record that Himmel played upon a harpsichord in public, at Berlin, as late as 1805. All the keyboard stringed instruments, whatever the size and however the sound may be produced, have certain structural peculiarities in common, and especially the apparatus for resonance, the barred soundboard, of cypress in the old Italian spinets, of spruce in the modern piano; all come under the same acoustic generalization of resonance, as Strad fiddles, Bologna lutes, or Andalusian guitars.

The piano-forte was invented by Cristofori, of Padua, in the first years of the eighteenth century, to satisfy the desire for a stringed clavier that should combine the expressiveness of the clavichord with the effectiveness of the harpsichord; it was, at first, a sufficiently facile instrument, and contained those principles of resonance—resistance to strain and suppleness of key action—that still characterize it. Cristofori solved three important problems, the first of which was to counteract the strain of the thicker strings necessary to withstand the impact of hammers. The second, allied to the first, was to compensate for the weakness caused by the opening between the turning-pin block—technically, "wrest-plank"—and the sound-board, imperative for the hammers to rise to the strings. The third was the mechanical control of the rebound of the hammer from the strings—technically, "escapement"—so that the hammer should not block against the strings and prevent vibration. All this he did, and more, for he invented the check, or movable rest for the hammer-tail, the simplest expedient to preserve the position of the hammer for a repeated blow—technically, "repetition." I am glad to be able to show models of Cristofori's actions, one made from the diagram in Scipione Maffei's account, published in the *Giornale dei Letterati*, A. D. 1709; the other, a remarkable piece of mechanism showing the check as well as the ingenious escapement, from grand pianos actually existing, dated 1720 and 1726. The much-talked-of pianos by Silbermann, acquired by Frederick the Great, and still at Potsdam, have Cristofori's action. Now if we raise the lid and look inside a modern grand piano, we shall see first the strings, three in number for each note, of cast steel wire—perhaps the strongest tensile material in the world—with the length and diameter increasing from the treble to the bass, and single bass strings for the lowest notes, overspun with fine copper or white metal wire to add to their weight, to make up for the strings in that part of the scale being theoretically too short. It may surprise some here to know that each of these three string notes, when up to the pitch of a London orchestra, has, in Broadwood's concert grand pianos, an average drawing power or tension of approximately 500 pounds, so that the notes have a strain, and that always when at that pitch, of nearly twenty tons. This large aggregate is exceeded by some foreign makers. To withstand this enormous strain, the strings are held at one end by coils round the tuning pins, which are driven into a strong structure of beech and wainscot, called the wrest-plank; and at

the other end are hitched upon smaller pins fixed into an iron or steel plate which is carried around the bent side to the end of the case. Their bearing points are upon the bridge attached to the sound-board, and the brass agraffes which collectively form the wrest-plank bridge. Bars of metal cross from the wrest-plank to the string-plate, and are so adjusted and fixed that the instrument proper is in an immovable iron frame. American and German makers have a single casting. Beneath the strings from where the hammers rise, to the bent side, back, and end of the case, is the sound-board of spruce fir, barred beneath with batons, usually of the same wood, technically "belly-bars," which strengthen the belly, and by increasing its elasticity, extend its power to form nodes or centers of vibration, and thus respond more promptly and effectively to the vibrations which are passed to it from the strings, when set in movement, through the hardwood belly bridge. A good sound-board reproduces all figures of vibration, however complex, exactly, and as freely as they are brought to the ear through atmospheric air, and re-enforces them so that the almost inaudible sound of the wires becomes the satisfactory fullness of tone we hear when a good piano is played. All pianos, upon whatever system they are made, have the features I have just described in common, also a wooden substructure of heavy beams, which keeps the case intact and rigid; but there are differences of application which are the choice of the makers, and are sometimes of their invention. In Broadwood's concert grand, one diagonal bar bears the greater part of the strain, its angle to the string plate being disposed with that object, while Steinway's and nearly all foreign grand pianos, have more bars, and the bass strings crossing the long steel strings, with the wider scale and expanse of sound-board permitted by that disposition. For me, the tone of an overstrung bass is unduly powerful, and is open to the same objection I have touched upon in large organs, that soft, pure basses are not attainable. We have reached an aggregate of power in the grand piano which almost silences the stringed quartet, and even competes with the full orchestra. What we want is a pianoforte tone that gives us all the power and all the charm of varying *nuance* we can desire, with a tone-quality as specialized in character as the harpsichord tone was, that shall have the brightness and energy of vibration of the trumpet, without the blare.

I must pass by the advisability of iron frames in a single casting, for which the great convenience and popularity place my own want of faith at some disadvantage, to make some reference to the not less important question of the mechanism or action. The hammers attack the strings with an almost incredible variety of velocities, according to the player's scale of force. It is wider and more various in the English action, and is, therefore, more open to the characteristic individual feeling for tone; while Erard's action, which, in principle, is generally adopted abroad, is considered far more facile for the pianist's *technique*.

The domestic upright piano is now restricted to the various modifications invented with the instrument about 1800, by Isaac Hawkins, and improved some sixty years since by Robert Wornum, the general merits of which have caused it to be, in these latter days, employed in every piano-making country.

The structure of smaller pianos is, in principle, the same as the concert grand. I have, in this paper, preferred to deal with the general principles of piano construction, rather than to touch upon the debatable points, which would take long to discuss, and could hardly be settled, inasmuch as piano making, like all other musical instrument making, is an art, and cannot be brought down to the level of mere mechanical manufacture. I think those who play the piano should have some acquaintance with those general principles, including that of sympathetic vibration, which the player controls with the pedals, a natural Æolian charm and prerogative of the instrument, divined by Beethoven, but the true use of which we owe to Chopin. I believe, if consideration were given to those principles more than it is, the unreasonable demands some players make upon this singularly responsive instrument might be reduced, and to the advantage of the cultivation of a feeling for tone which is incumbent on wind and other stringed instrument players, but is too frequently disregarded by those who play the piano.

I ought to refer the inquirer for further information about the construction of the piano to my paper upon it, read before the Society of Arts, March 7, 1883.*

OSCILLATIONS OF SHORE LINES.

DR. NANSEN, the Swedish explorer, during his recent visit to London, described the results of his investigations and theories regarding the phenomena of "Oscillations of Shore Lines," before the Research Department of the British Royal Geographical Society. The variations in the comparative level of land and sea is a question to which the eminent explorer has devoted a great deal of attention, and his results are of great interest to geographers. As Dr. Nansen pointed out, this question is a widely controversial one, opinions being very divergent regarding the nature and causes of variations in the shore line of the continents during geological ages. One popular contention is that the continental coasts have even recently been subject to great oscillations of level—that at some places the coasts have been much elevated, while at others they have been depressed, and that they still remain at these different levels. This opinion, however, he maintains to be fallacious, and he states that a thorough and systematic investigation of the problem would show this view to be incorrect; for there were many and strong evidences that, though there had been great oscillations of level, the mean level of the continental shore lines had for long geological periods past been very nearly the same as to-day over vast regions of the earth.

According to Dr. Nansen the coastal platforms and terraces formed by the so-called marine denudation—marine and atmospheric erosion combined—afford the best means of studying the problem. In this connection he discussed the characteristics of the coast platform and continental shelf lying off the Norwegian coast. The former extending from Christiania to Finmarken, and comprising the almost continuous belt of low islands and skerries that fringe the mainland, are situate between 100 feet below the present sea-level, and 100 feet above it. Probably the platform was formed in glacial and interglacial times. The continental shelf varies greatly in depth and width. At some places it is high and narrow, lying at a mean depth of from 200 feet to 300 feet, while at other points it is very broad and deep, lying from 700 feet to 900 feet below sea-level. To a very great extent this continental shelf must be composed of rock and must actually have been cut by erosion, though the coastal deposition of continental waste also played an important part in the building up of continental shelves. Being largely cut in the solid rock, the Norwegian shelf could not have been developed at present sea-level, but must have been formed during periods of vertical oscillations of the shore line. As in the case of the coast platform the shelf would be cut to its lowest levels where the coastal rocks were comparatively soft, or where the marine denudation was most active. This investigation combined with the consideration of the conditions prevailing in other parts of the world, furnished strong evidence that during recent geological periods the level of the shore line along most continental coasts had oscillated much below as well as above the present level. A very important and striking fact, notwithstanding these great oscillations, is that the shore along nearly all coasts is at the present moment, very much at the same level as it was during by far the greater part of recent geological periods. Forty-two per cent of the continental surface of the earth stands between 600 feet above and 600 feet below the present sea-level. In Norway the coast platform is situate very nearly at its present level, though in post-glacial times it had been depressed in places 700 feet below its present level, while in other places the depression had been very much less—only 30 feet to 60 feet. Consequently, in spite of this great difference in its depression, the coast had afterward been elevated almost exactly to the level at which it stood before depression. This appeared to prove that the land, or crust, had a remarkable tendency after disturbances of its level, to return to a certain mean position of equilibrium. In his opinion, in Norway during the last glacial epoch the land had been pressed down by the weight of the ice-cap, and when this weight was removed the crust gradually resumed its former level. While, however, oscillations in the shore level were thus due to movements of the earth's crust, a survey of the available evidence shows that the level of the ocean has, on the whole, risen to an appreciable degree during late geological times.

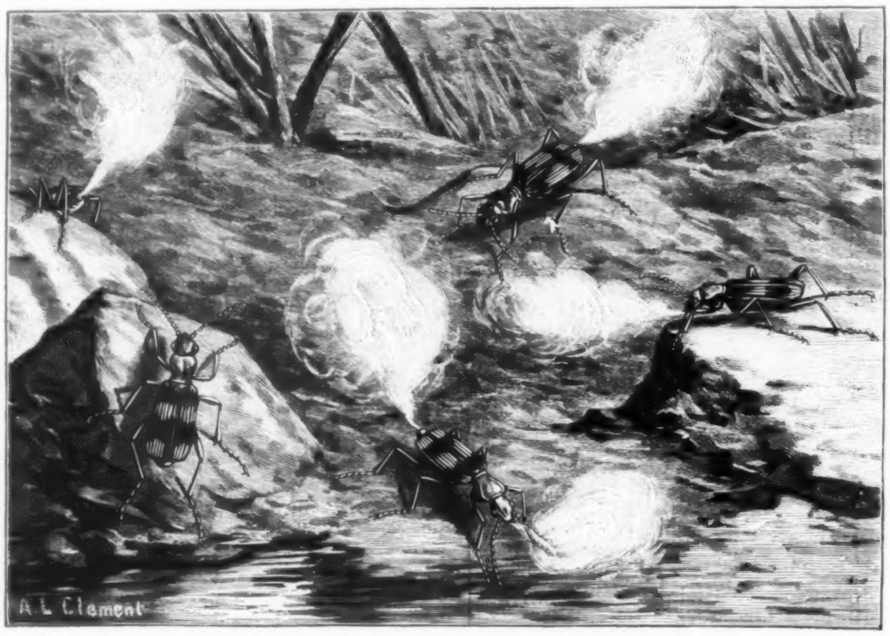
FISHING IN THE PHILIPPINES.

As fish forms one of the principal articles of food, one of the most important occupations in the Philippine Islands is fishing, but the extent of the industry cannot be estimated readily, as a large proportion of the people assist in the maintenance of their families by this calling, but few devote themselves to it exclusively. Only 3.8 per cent of the producing class were reported as fishermen. The census supervisors reported that fish forms the principal article of flesh diet for about nine-tenths of the Filipinos. The annual consumption approximates half a million tons, or 800 pounds per average family. It is estimated that 119,000 persons are engaged to some extent in this calling, employing 28,000 boats. An industry followed by the Moros of the Sulu archipelago is fishing for pearls, mother-of-pearl shells, and sharks.

CURIOUS INSECTS OF THE AMAZON.

THERE exists in the region of the Amazon a variety of insects which are provided with a truly remarkable means of defense. These are coleoptera of the genus *Cicindela*, with thorax and legs of a light brownish yellow, black elytra marked with yellow, and of a total length of from 0.6 to 0.7 of an inch. Although these insects are sometimes seen in the daytime, it is at night that they can most easily do their hunting. "In the paths of my garden," says M. Le Cointe, in La Nature, "by directing the light of a dark lantern toward the ground, I have seen them running in all directions seeking a refuge in the clefts between the stones of the borders, or concealing themselves under tufts of grass. Every time that I have tried to seize one of them, a slight noise has been heard like that of steam under pressure escaping from a valve raised by jerks, while a jet of smoke has made its exit with force, in most cases from the extremity of the abdomen, and sometimes even from the mouth, and disseminating a strong odor of nitrous gas.

"At such times I have experienced quite a strong feeling of heat in the hand, and the body of some of the insects that I succeeded in catching appeared to me to be hot. My fingers and the parts of my hands that had been touched by the hot smoke were stained an indelible brown. It would seem as if this were



A DRAGON IN MINIATURE—PHEROPTOPUS ŒQUINOXIALIS.

a very caustic substance which the insect projects with violence in an impalpable dust against the enemies that threaten it, and that it holds in reserve for important occasions.

"This process is not absolutely abnormal, since a number of other animals also have recourse to projections of liquids or odors against their enemies for their defense. But this denotes in our insect both a special chemical talent and a special resistance of the intestines that may be qualified as most remarkable.

"Upon the whole, this little coleopter is nothing less than a dragon that projects fire and flame from both of its extremities and that differs in principle from the famous monster of antiquity only in its dimensions. It may very well have been that our ancestors also knew some gigantic cicindele, the remains of an antediluvian fauna, and that they have not prevaricated as much as might seem to be the case in relating to us the misdeeds of the marvelous and terrible animal committed in the days of yore in guarding caverns in which was hidden every sort of treasure worthy of the name."

N-RAYS.—O. Rosenbach writes a "critique of the N-ray problem," in which he takes the view that the N-ray phenomena are not actually seen by the normal observer (though this has been denied), but are due to an unconscious visualization of muscular processes. He describes an experiment in this connection which, he maintains, everyone can perform with ease. In a perfectly dark room the hand is held before the eyes. The fingers will then be seen black on a background filled with vague luminous impressions such as are always present. On moving the fingers, their motions are seen. The vision is, of course, not real, but due to an association of ideas which has by habit become irresistible.—O. Rosenbach, Physikalische Zeitschrift, March 16, 1905.

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OUR SUN AND "WEATHER."*

By WILLIAM J. S. LOCKYER, M.A., Ph.D.

THERE are many of us who would like to know whether our next summer will be sunny and warm or our next winter dry and cold, so that we might prepare for the delights that could be enjoyed by such

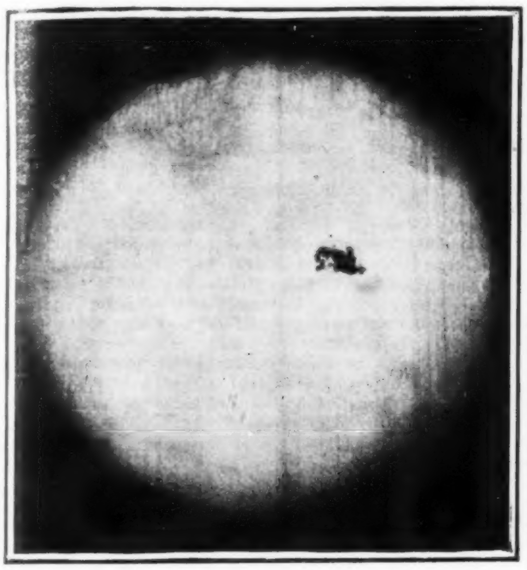

Fig. 1.—The Sun, as photographed with an ordinary telescope, showing the spots on his disk, taken about the time of sunspot maximum.

weather conditions. That day is not, however, with us yet, and its delay in coming is owing to many reasons, the chief among which being that civilized nations were not so widely scattered over the earth as they are now, and that consequently meteorological records extending over a long period of time do not exist in sufficient number to allow of a complete discussion being made.

If we only had behind us one hundred years of good meteorological observations made in the way that they are to-day, and also an unbroken record of observations of sun-spots and prominences, then we should be in a far better position to tackle such meteorological problems as are now lying before us unsolved.

Unfortunately one cannot go much further back than about fifty years when discussing the great majority of meteorological observations, for in many cases they are either very sparse and broken, or it is not known with what degree of accuracy they were made. In the case of solar phenomena the investigator is still more restricted; for, although the observations of sun-spots have been made in a more or less crude manner for a great number of years, it was not till about the year 1830 that a systematic method of observation was adopted; further, the solar prominences, important indicators of the sun's activity, were only first recorded systematically in the year 1872. The reader will therefore understand that before all these different phenomena can be correlated to enable long-period forecasts to be successfully made, a greater period of time than the one at present available is absolutely necessary.

This is, however, no reason why attempts should not now be made to find out whether these solar and terrestrial changes are related to each other, and if possible to point out how, from our present material, such a relationship, if detected, can assist us in making at any rate rough forecasts of approaching seasons.

It is generally acknowledged that we are children of the sun, and life on this earth is only possible in consequence of his presence. Our sun is, so to speak, the fuel on which we are all dependent, and it is, therefore,

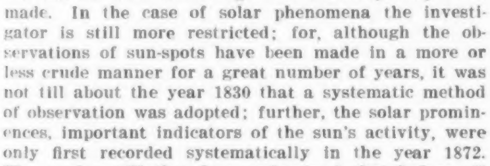

Fig. 2.—The dark portion shows the variation in the amount of the total spot area on the Sun from year to year for an eleven-year period. Notice the three prominent outbursts in the years 1870 and 1871.

fore, quite natural to look to him as the instigator of our "weather." Now, our orange-shaped globe is surrounded by the atmosphere. The sun from without pours his rays down on the earth's surface and heats it, whether it be water or land; this heated land or water warms the atmosphere in contact with it, and this warmed air, which is now lighter than it was before, rises from the surface and is replaced by the cooler and heavier air flowing in at the bottom. In this way a current of air, a wind, is set up. The land or water most heated in this manner is that which lies in those regions over which the sun during a year passes overhead, and the reader will at once gather that this part of the world is that which includes the equatorial regions. It is due to the heating of this region, coupled with the great cooling about the terrestrial poles in consequence of the presence of ice and snow, that the whole mechanism of the circulation of the atmosphere is set in motion and maintained, and "weather" is the ultimate result of this circulation. Fortunately for us—but unfortunately for meteorologists—the surface of the earth is not completely covered over with water, but is studded here and there with great stretches of land, so that an unequal heating of the atmosphere round the equator takes place, and the directions of the atmospheric currents the further the equator is left behind, combined with the rotation of the earth, become more complicated than they otherwise would be.

To study the action of the sun on the earth to its fullest extent it is therefore best to begin in the region about the earth's equator where the solar action is greatest; and when this is completed, to trace this action, which would probably be communicated by the air currents, to the regions in higher latitudes.

It is well known not only in these but in all other latitudes that the "weather" is not the same every year. Sometimes there is a great abundance of rain, sometimes very little; one winter is very mild while another is very cold. In fact each continent has its own little meteorological worries such as floods, droughts, famines, etc. Thus India has just recovered from the most severe famine ever known while Australia is laboring from a similar visitation. There seems little doubt that all these conditions are produced by changes in intensity or direction, or both, of the main currents in our atmosphere, and since these conditions depend for the main part on the distribution of atmospheric pressure, it is this element which should receive the closest attention.

It has been stated above that the most likely cause of these variations finds its origin in the sun, for, granting a change in his heating powers, the strength of the atmospheric currents, and consequently the atmospheric pressure, would be accordingly altered.

The question therefore arises, Does the heating power of the sun vary? This is difficult to answer directly, although from certain observations of his surface, to which reference will now be made, the deduction is that great heat variations do occur.

If the sun's disk be scanned from time to time, it

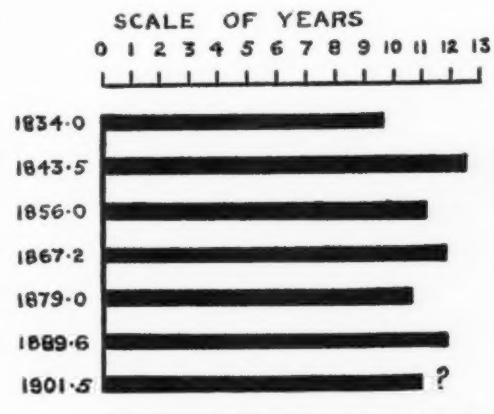

Fig. 3.—The lengths of the period from minimum to minimum change alternately.

will be found that sometimes there are spots and sometimes there are none (Fig. 1). According to our present knowledge these spots are produced by the descent of comparatively cool matter from the higher reaches of the solar atmosphere, so that the more spots there are, the greater the quantity of matter descending. Since this falling material is the result of previous uprushes of highly heated matter from the lower levels of the sun's atmosphere, it stands to reason that this spot phenomenon indicates great solar atmospheric disturbance and therefore greater activity and consequently more intense heating capacity. Thus we arrive at the conclusion that the greater the number of spots, the greater the solar activity and therefore the hotter the sun.

Now there is a decided periodicity in spot activity. For some years only a few spots become visible, while a little later they become more numerous until a maximum is reached, after which they begin to dwindle again in numbers until the succeeding minimum is attained, when the sun remains spotless for months together. The accompanying diagram (Fig. 2) will give the reader a good idea of this variation. The dark portion, which looks like a silhouette of a cathedral city, shows the change of the amount of "spottedness" of the sun for each solar rotation from the year 1867 to 1879; the arrows indicate the "epochs" or times, as determined from a curve specially smoothed for this purpose, when there are fewest (minimum) or most (maximum) spots. It will be noticed that there is not a gradual increase of spotted area, but that, as the diagram shows, there seem to be intermittent outbursts. From this figure, which includes a whole sunspot cycle, it will be seen that the time from one minimum to the next is about twelve years; this, however, is not always the case. A glance at the next diagram (Fig. 3) shows that since 1834 the lengths of these periods are alternately longer and shorter than the preceding one, the mean length being a little more than eleven years. It will thus be seen that the so-called "eleven-year cycle" of sunspots is only *approximately* true. A reference again to Fig. 2 shows further that the epoch of maximum occurs nearer the preceding than the following minimum; this is always the case, only from one period to another this interval from minimum to maximum is not the same. To illus-

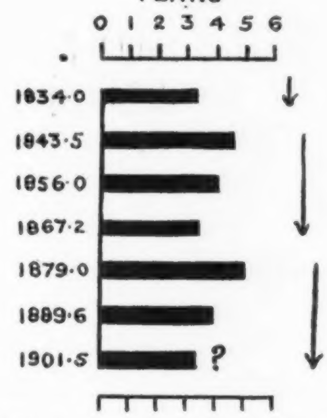

Fig. 4.—Diagram to show that the interval between a minimum and the following maximum changes in a cycle of about 35 years.

trate this, these intervals are arranged in Fig. 4 one below the other, and instead of an alternate change in length they recur every third period. Thus if this apparent law holds good the approaching maximum will occur about a little more than three years after the last minimum (this occurred in about the middle of 1901), that is about the end of the present year (1904). Another curious fact relating to the sun-spot cycle is that when the interval from minimum to maximum is shortest, the total amount of "spottedness" included in the whole period from minimum to minimum is greatest. This is graphically shown in the accompanying diagram (Fig. 5). The last square represents the relative spotted area that may be expected for the present cycle if the previous conditions be repeated.

The above brief summary of the sun-spot variations tells us that not only does the heat of the sun change, but that these changes occur in cycles of about eleven and thirty-five years. There is, further, another cycle,

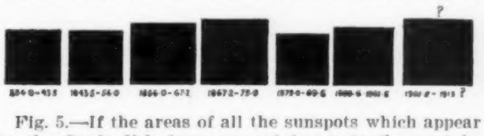

Fig. 5.—If the areas of all the sunspots which appear on the Sun's disk from one minimum to the next be added together, then the above squares show the relative change of spotted area for each of the periods from the year 1834.

not very well indicated, which has a period of less than eleven years, probably the same as that which is more clearly defined by the solar prominence observations to which reference will now be made.

The solar activity can also be gaged from "prominence" records. These disturbances are probably of more consequence than those of spots. The latter are strictly limited as regards position on the sun's surface

Fig. 6.—A picture of the Sun taken in light of one color, showing that there are other areas on the solar disk which are more extensive than those of spots. The former appear bright while the latter are dark.

to a comparatively narrow zone near each side of the solar equator, while there seems no such restriction to the former. Again, if the relation between the areas of spots and prominences be considered, those of the former are practically insignificant. A study of prominences is therefore of the highest importance when the activity of the solar atmosphere is in question, but, unfortunately, records of these only commence in the year 1870. Unlike spots, which, as pre-

* Knowledge and Scientific News.

viously pointed out, are the result of the descent of comparatively cool matter from the upper regions of the solar atmosphere, prominences consist of ascending currents of highly-heated matter from the lower to the higher layers; indeed, they are the precursors of spots and are thus more direct indications of solar disturbances. That they are very important factors in solar "weather" can be gathered from their enormous magnitudes, some of them being 100,000 miles or more in height and correspondingly broad.

Prominences, like spots, have periods of maximum and minimum frequency. As a rule, when there are few spots there are few prominences, and when the spotted area is large so is that of the prominences. There is thus a very close connection between these two phenomena; but it must be stated that this connection only holds good when the prominences situated nearest the equatorial regions of the sun are alone taken into consideration. It is due, however, to the fact that prominences are at times very numerous near the solar poles that the curve representing the mean variation of their frequency from year to year does not rise or fall gradually throughout a cycle, but is of a wavy nature, as can be seen by a glance at the curve shown in a subsequent figure (Fig. 7). It is this peculiarity that makes the prominence curve so important, for these "humps" on the main curve represent solar changes of activity that are scarcely traceable on the spot curve. There seems reason to believe, therefore, that the observations of prominences are capable of giving us far more information regarding the circulation and activity of the solar atmosphere than those of spots.

We thus see then that the study of spots and prominences has made us acquainted with three different periods of solar changes. Thus we have a short period of a little less than four years, another cycle covering in the mean a little more than eleven years, while a third variation occupies about thirty-five years.

Having thus briefly summarized the chief facts concerning the various changes of solar activity, attention will now be paid to the records of meteorological phenomena to see if any trace can be found corresponding to these solar variations. The question now arises as to which meteorological element should be chosen to commence operations with. For several reasons, which need not be mentioned here, barometric observations have been selected, for they supply us with an excellent means of detecting variations of pressure which are direct indicators of air movements toward or away from the earth's surface. Greater solar radiation means greater heating power, and therefore stronger ascending currents away from the earth in some parts of the world, and consequently greater descending currents in other parts; thus we should expect to find lower and higher pressures simultaneously in different regions of the earth's surface.

A decided great advantage in employing barometric records is that the variations of this element from year to year are very similar over large areas, and do not change according to local conditions as is the case with rainfall. Thus, to take the case of the British Isles, for example, the pressure variation of, say, Oxford is quite sufficient to illustrate the variation over the whole of the British Isles, as if we employed the records of Valencia, Aberdeen, Greenwich, or Edinburgh, which are also quite similar. Rainfall is the *effect* and not the cause of barometric pressure variations, and we in these islands are quite familiar with this fact. A fall in the barometer with us generally means rain, and a rise probably dry weather. Rainfall then being an after-effect of pressure, any variation of the latter should have a very close connection with the former.

(To be continued.)

ATMOSPHERIC PRESSURE AND CHRONOMETRY.

From the French of DR. CH. ED. GUILLAUME, Associate Director of the Bureau of Weights and Measures, in La Nature.

THE idea of investigating the action of the atmosphere on the rate of chronometers is not absolutely new. As early as 1826, Urban Jurgensen, the celebrated horologist, made experiments in this direction and demonstrated that such action really exists; but the results were to a certain extent contradictory and imperfect; they have been generally ignored by horologists. In 1888, M. Hilfiker, then astronomer at the Observatory of Neuchâtel, took a step further and showed that retardation always takes place when the atmospheric pressure is augmented. The results he arrived at, however, were too few and variable from one chronometer to another to allow of establishing a regular law of the phenomenon.

These two attempts which, while indicating the reality of the action in question, were not susceptible of generalization, showed the importance and the complexity of the problem. The question is distinct from that of the duration of the oscillation of a pendulum in a dense and resistant medium. Here, an action is evident and can be calculated very easily; this is the force of the air diminishing the action of the weight on the pendulum, and consequently its static moment. But though this action is preponderant it does not exist alone; the air drawn by the pendulum increases its moment of inertia, the slackening of the oscillations acts on the isochronism, and from these three combined effects results a retardation when the density of the surrounding medium is increased.

The action of the air has been studied by Buat, Bessel, Stokes, and, more recently, by Col. Defforges. The global effect is so well known that for many years astronomical clocks have been kept in hermetically sealed inclosures, where the density of the air is constant. Without this precaution all changes of atmospheric pressure influence the rates, as our lamented Tisserand has shown in his study of the variations of the principal clock at the Paris Observatory.

For chronometers, the solution is not so clear; for the loss of weight due to the action of the medium does not take place, since the momentum which brings back the mobile to its position of equilibrium is supplied by a spiral spring, and not by weight. The other effects exist alone, and it is difficult to tell in advance which of the two will be preponderant. So, while retardation of clocks under the action of pressure was an established fact, several of those who had considered the theoretic question in regard to the chronometer most successfully, foresaw a gain in the rate under the same conditions. In his celebrated memoir on the compensation of chronometers, Villarceau confines himself to a calculation of the movement of the balance in a resisting medium, and concludes that there is only an action of the second order in importance. Caspari, while recognizing the tendency to retardation in marine chronometers when descending from mountain to sea, attributes this action, not to greater density of the air, but to greater humidity; according to him, increase of pressure causes a gain, and that for the same reasons that Villarceau had alone considered.

Thus this question was not solved by the theoretic researches or by practical experiments, and a more systematic study was desirable.

Recently, the distinguished horologist, M. Paul Ditisheim, undertook anew to determine the difference between the longitude of the observatories of Paris and of Neuchâtel. It will be seen at once that it was not a question of bringing this method into competition with the more direct method of telegraphic communication of the time, such as is realized by the recent progress made in telegraphy. The attempt of M. Ditisheim had as an object rather the degree of precision that it is possible to attain in such a case, by taking advantage of all the resources that the perfection of modern chronometers places at our disposal.

A number of marine chronometers of the best construction were thus observed at La Chaux-de-Fonds, at a height of 1,017 meters, then at Neuchâtel, at 489 meters, and lastly at Paris, at 67 meters, after which they were taken up the mountain again. Now, a comparison of the daily rates at these three stations immediately indicated a regular advance in the rate, the chronometers losing time in proportion to the descent. A subsequent determination made at Chasserel at 1,586 meters, allowed of prolonging the curves, giving them more reliability.

These observations of Mr. Ditisheim were followed by me with the greatest interest. M. Bijourdan of Paris, M. Arndt of Neuchâtel, and M. Berner of La Chaux-de-Fonds, lent their aid, and M. Ditisheim kept me acquainted with the progress made. I offered various suggestions for conducting the observations under the best and easiest conditions, and he did not hesitate to install in his factory apparatus that enabled him to expose chronometers without derangement at pressures varying gradually from about a tenth of an atmosphere to two hundred millimeters above the average pressure at La Chaux-de-Fonds.

There are a number of questions to be solved in a problem like the present; the first that present themselves are these two:

What is the form of the function that connects the rates of a chronometer with the density of the surrounding atmosphere?

How do the coefficients of this function vary relatively to the dimensions of the chronometer?

To afford an answer to the first of these questions, seven chronometers 42.6 millimeters in diameter were submitted to regularly increasing pressures by gradations of 100 millimeters of mercury over a total extent of 800 millimeters; then the dual values of pressure and of the daily rate being ascertained, the parameters of the most probable right line passing between all the points thus determined, were calculated. The calculated right lines pass regularly between the figurative points of the observations, systematically leaving no group out; this, confirmed with great exactitude by the average of the seven chronometers, shows that, within the limits of precision that these chronometers allow of attaining, and in the intervals of pressure in which they were studied, the variation of the rates is simply proportional to the pressure. The deviations of the calculated right line are extremely slight, showing the remarkable perfection of the time-pieces employed in these observations.

But a comparison of these results brought to light an unforeseen irregularity. While for the same chronometer the observations described a well-determined coefficient of variation, this coefficient differed for each chronometer, though their construction was identically the same. I surmised that these divergences were closely related to want of isochronism in the time-pieces; that is, to the difference of the duration of oscillation of the balance in the large and small arcs, occurring when the chronometer is being wound up, or when the spring reaches the end of its course. M. Ditisheim immediately undertook tests which confirmed this opinion absolutely. It may be proved by means of a diagram on which are represented in abscissas the retardations per millimeter of mercury and per twenty-four hours of observation; in ordinates, the gain of the chronometer in the small arcs, a gain generally desired from its assuring greater regularity in instruments carried in the pocket.

The relation between these two values is evident; the nearer the isochronism reaches zero, the greater is the retardation. In this is to be found the knot of the question and the reason of the divergences occurring both in the theoretical examination and in the practical tests of the chronometers submitted to pressures.

The air acting as a resisting medium diminishes the amplitude in proportion as its density is greater; it increases in the same degree the effects of want of isochronism. It is on these effects that Villarceau and Caspari have specially laid stress. But the preponderating action in this case is a manifest retardation, greater than the effect of isochronism in the time-pieces observed by M. Ditisheim, of which it is not difficult to discover the reason. In its movement the balance draws the air, communicates to it its kinetic energy, and thus itself increases the mass oscillating under the action of the spring, and consequently its moment of inertia and the duration of its oscillation. For instruments of the type under consideration, it suffices to suppose around the spring an adherent ring 3.2 millimeters in section, in order that the retardation observed may be fully explained. It is to be remarked that the air taken at the center of the balance is driven by centrifugal force toward the outside. It therefore reaches the periphery only with radial velocity, which there quickly becomes tangential velocity; its mass is thus virtually augmented.

The first question is now satisfactorily answered, experimentally and theoretically. M. Ditisheim has verified the suction of the air by watching the movements of a gold-leaf suspended within about 6 millimeters of the balance. Small radial oscillations were observed.

The suction being now demonstrated, it will be seen that the action of the ambient medium does not depend only on its density, but also on its viscosity. As the two factors are modified by the temperature, no doubt the compensation depends upon them in an appreciable degree. The diagram referred to, suitably prolonged, permits also of readily seeing that for watches of tested caliber, the retardation for each millimeter of mercury would be 0.0162 second in twenty-four hours. On the other hand the action of the pressure would be nil, if the defect in the isochronism reaches 12 seconds. Thus, watches insensible to pressure could be made, but then the want of isochronism would occasion inadmissible irregularities of rate, much worse than the influence due to variations in the density of the circumambient air.

The second question, solved by observing time-pieces of different calibers, has shown, as was to be expected, that the action is all the more energetic as the watch is the smaller; in a lady's watch it is twice as strong as in a marine chronometer; but this is not of much importance, considering the degree of precision attainable in such small watches and the accuracy expected of them.

It now remains to notice the practical consequences to which M. Ditisheim's observations lead. Let us take, as an example, a deck watch, which is *par excellence* the time-keeper of explorers and aeronauts. We have seen that such an instrument, perfectly isochronous, loses 1.62 seconds per twenty-four hours, when the augmentation of the atmospheric density corresponds to an increase in pressure of 100 millimeters of mercury. Supposing a watch of this type is carried on a journey, such as crossing the high table-lands of Thibet, at an average altitude of 4,000 meters. In consequence of a decrease of the pressure, the chronometer will gain almost 5 seconds a day, which in a month will amount to 2½ minutes. Then suppose that at the end of these thirty days the determination of the longitude is to be made, there would be an error of 37 minutes of arc, corresponding, in the latitude of the plateaus of Asia, to a linear deviation little less than 100 kilometers. This is a relatively rare case, but it is not extreme, for harder conditions have been imposed upon explorers of the elevated regions of the earth. It is certain, for instance, that on the celebrated journey undertaken some years ago by M. G. Bouvalot and Prince Henri d'Orleans, the variation in the rate of chronometers in our supposed case might have been exceeded.

Deviations of a few myriameters in the determination of an astronomical position may give rise to great miscalculations and even serious danger. In future these will be easily guarded against by adding to the usual tests of chronometers an examination under pressures, at least when the instruments have to be taken into mountainous districts.

Belts cannot be figured for the strength in direct proportion to the number of plies as can be iron or steel, because iron or steel is homogeneous and its strength is in direct proportion to the area of cross-section. Belts are formed of a number of plies of canvas, cemented by friction (a technical term used to denote pure rubber in connection with naphtha spread on the surface and forced into the fiber of the canvas and then vulcanized). The bond or cement is never in practice found strong enough to withstand shear under all circumstances of use of the belt. The same canvas woven at different times, or at practically the same time, subject to varying atmospheric conditions, produces a close or loose weave, having a greater or less amount of stretch, resulting from these atmospheric causes; so that initially, due to practical inability to produce absolute uniformity, there is a decided variation. The facts are that a completed belt of any number of plies (above a one-ply belt) takes up the tension gradually, the tightest ply giving until the next combined with it meets the tension of the third, and the third in combination giving until they meet the requirements of the fourth and so on through

the series, with the result that some plies are stretched beyond what they should be. The fewer the plies in a belt the less is the tendency to subject some plies to more strain than others, on account of the above causes. A thick belt is very likely to be so strained and its total strength is therefore not in proportion to the number of plies, whereas with a thin belt this is more nearly the case.—Mines and Minerals.

ELECTRICAL NOTES.

A new form of electric radiator has been devised in which the radiating material, comprising resistance wire, is wound round square porcelain tubes with concave sides, each tube constituting a separate unit. These tubes are placed in a casing in such a manner that rapid circulation of the air without deterioration or burning may be attained. The heat is regulated by switching on separate tubes or units.

We learn from an exchange that an Indiana genius proposes to utilize cats for the generation of electric current for lighting. His purpose is to round up the cats and drive them through a chute, so that they will pass under rotating brushes which will abstract the desired current. The invention might be further improved by the employment of mice, so that the cats could be drawn through the chute by induction. Just how much feline power is required to light an incandescent lamp has yet to be ascertained.

Owing to the frequency of the fatal cases of electrocution that have occurred upon the electrified section of the North-Eastern Railroad of Great Britain, the railroad authorities are carrying out a series of interesting and important experiments, with a view to minimizing the risk of shock from the "live" rail. A new type of ballast almost white in appearance is being laid down in substitution for the ashes which have heretofore been employed. This new material is composed of small chippings, and is being laid down for a distance of two or three inches below the wooden railroad ties. This new ballast material is of less conductivity than the ash ballasting, and consequently much safer for the employes to walk upon.

Various metals which are themselves non-magnetic may form alloys which display magnetic qualities; some of these have been produced in recent experiments. Aluminium, copper, and manganese are all non-magnetic, but when combined in certain proportions an alloy of considerable magnetism is produced. As no alloy of copper and aluminium alone is magnetic, this effect must be ascribed to the manganese, and yet this metal alone, as well as copper and aluminium, remained non-magnetic when cooled to the temperature of liquid air. An alloy of manganese with iron is practically non-magnetic, but with the same manganese a magnetic copper alloy can be made.—Engineering Review.

It is suggested by German electricians that one of the solutions of the photography of colors may be found in the employment of electrolytic processes by the use of a body which like selenium has an electric resistance variable with the light and of utilizing the body as electrode. The image to be produced being then projected on this electrode, a galvanic deposit would be formed with more or less rapidity, according as the spot might be illuminated with more or less intensity. The application of this principle presents at first sight numerous difficulties. Experiments have been made in preparing plates of different kinds and of employing them as anodes, after exposure to the light, in a bath containing lead oxide in solution in a potash lye. The experiments are not yet concluded.

The telekin is the name applied by Mr. L. Torres in the Comptes Rendus to an apparatus by which the movements of a machine may be regulated from a distance, either by means of an ordinary electric telegraph or by electric waves impelled through the air without the aid of wires. The inventor distinguishes between a simple telekin, wherein only a single motion is considered, and a multiple telekin, which permits of a complexity of motions. The simple Telekin consists of a sort of needle telegraph, in which the needle slides over a number of contact points, whereby the circuit of an electric motor is closed. The motor imparts motion to the apparatus to be steered, for example the rudder of a boat. According to the plans of the inventor, there are three methods of steering: 1. The needle functions like a commutator; that is, three separate positions of the needle correspond with the three requirements—ahead, rest, and astern. 2. Upon the axis of the needle there is adapted to move freely a contact disk which contains two metallic segments of nearly 180 deg. each. The needle contacts slide over these segments, and the motor continues to turn the disk until the needle comes to a point of insulation, when it will be found that the disk has revolved through the same arc as the needle. 3. Steering by the compass, in which case the compass touches contact points, and the motor acts direct upon the rudder.

In the multiple telekin several distinct apparatus are actuated by means of a wireless system. To bring each one of these separate appliances into action, a system of long and short electric impulses is employed. Long impulses actuate the individual devices by cutting the circuits belonging to them in through the medium of a distributor. This distributor consists of a heavy metallic disk, which is revolved by a spring motor, being at the same time provided with a locking pin. Through the action of an electro-magnet this pin is periodically withdrawn and the disk freed; whatever contact points are in touch with the disk at the time close the circuit of their respective apparatus.

ENGINEERING NOTES.

Comparison of Metal and Wood Crossties for Railways.—Herr Benkenberg publishes in Stahl und Eisen a comparison based on recent investigations. According to his figures one kilometer of iron track would, after deduction of the value of the old ties, cost 8,117 marks; with metallic crossties of the model 51 E of the Prussian State, only 7,656 marks. A duration of a dozen years can be counted on for the first, and of fifteen years for the second, so that the saving by the latter is 23 or 24 per cent.

A furnace has been designed by M. A. Gomes for the purpose of obtaining very high temperatures, using the reflected solar heat. Temperatures above 3,500 deg. C. are said to be anticipated. The reflector is built up of 6,170 elementary mirrors, each 122 millimeters by 100 millimeters, arranged side by side in parallel rows, and are attached by threaded standards to a series of parallel angle irons, which run horizontally across the frame. The width at the top is 35 feet, at base 18 feet, and depth 35 feet.

Tests made by a French engineer to ascertain the tractive resistances of various forms of tires for motor car work gave the following results: Solid rubber, 33 pounds to 39.6 pounds per ton; pneumatics, 90 millimeters cross-section, 44 pounds to 53 pounds; pneumatics, 90 millimeters, not fully inflated, 53 pounds to 61.6 pounds; pneumatics, 120 millimeters, 64 pounds to 70 pounds; non-skidding band of leather with studs, 8.8 pounds in addition to the above. The results were obtained on good dry macadam, free from dust, at 13 miles per hour.

Two Belgian industries which owe their existence to the release of methylated alcohol from duty, viz., the production of ether and the manufacture of artificial silk, have already become important; the amount of alcohol used in these two industries in 1903 exceeded 880,000 gallons. A rapid increase has taken place in recent years in the amount of methylated alcohol used for industrial purposes consequent upon relief from taxation. In 1896 the consumption was only about 100,000 gallons, whereas in 1903 it rose to 1,323,784 gallons.

Recent Development of the Siderurgical Industry in Upper Silesia.—At a late sitting of the Metallurgic Association, Herr Witte presented a communication which is reproduced by Stahl und Eisen, from which it appears that the production of castings rose from 531,000 tons in 1894 to 748,000 tons in 1903. The iron ores used proceed principally from Sweden, Styria, Hungary, and southern Russia. The native iron does not represent more than a sixth of the production, and is not half as rich as some of the ores from other points. The transportation of the Swedish costs 7 marks ($1.75) per ton from the port of Stettin to the foundries; that of Hungary and Styria from 7 to 10 marks ($1.75 to $2.50) from the mines.

Since the attention of the people in Colorado has been turned to the subject of oil, and the possibility and probability of petroleum deposits below the surface, some curious natural phenomena have been observed which in several cases have led to the putting down of wells in search of the coveted petroleum. Chief among the phenomena are volcanic dikes, usually of basaltic lavas, in various portions of the State, which on being broken show a considerable amount of oil in their pores, and between their crevices. A popular, but we think, erroneous idea as to the origin of oil in these volcanic rocks is that it came up in some manner, difficult to conceive, in the lava when it was in a hot molten state. One can hardly imagine how so volatile and inflammable a matter could be brought up and retained in lava when it was in a molten condition. We know that lava when it first comes to the surface is so highly charged with steam that it pours forth more like steaming hot porridge than a molten rock.—Mines and Minerals.

According to the authority of Mr. J. M. Gledhill, of Armstrong, Whitworth & Co., ordinary crucible steel containing 1.30 per cent carbon is suitable for small turning and planing tools, drills, small cutters, razors, and surgical instruments; 1.15 per cent carbon for heavier turning, planing and slotting tools, drills, cutters, reamers, and engraving tools; 0.90 per cent carbon for large circular cutters, reamers, taps, dies, heavy turning tools, and large drills; 0.80 per cent carbon for cold chisels, hot sets, small shear blades, and large taps; 0.75 per cent carbon for dies, cold sets, hammers, swages, minting dies, miners' drills, blacksmiths' tools, punches, and shear blades; and 0.65 per cent carbon for snaps, dies, drifts, hammers, and stamping dies. The steel that is suitable for making a razor is obviously totally unfit for a stamping die, although it is of much higher grade and more costly. Much of the trouble encountered in the average shop in the use of tool steel is that no record is kept of the carbon content of the various steels kept in the tool room, and very often an entirely too high grade steel is used for a purpose where one of perhaps half the carbon content would be much better suited. Some shops paint one end of all steel bars in colors and combinations of colors which correspond to an arbitrary classification. As these bars are used, the stock is cut off the opposite end, and the marked end remains until the bar is completely used up. Where this or a similar system is employed, a large part of the trouble of the toolmaker should be avoided.—Machinery.

TRADE NOTES AND RECIPES.

Waterproof Coating.—Resin oil, 500 parts; resin, 300 parts; white soap, 90 parts. Apply hot on the surfaces to be protected.—Science Pratique.

Another Waterproof Coating.—A good coating may be produced by mixing 1 part of yellow wax and 3 parts of linseed oil prepared with litharge. For preserving stone walls from moisture, heat strongly; it will penetrate the stone.—Science Pratique.

Fireproof Coating.—A fireproof coating (so-called) consists of water, 100 parts; strong glue, 20 parts; silicate of soda, 38 deg. Baumé, 50 parts; carbonate of soda, 35 parts; cork in pieces of the size of a pea, 100 parts.—Science Pratique.

Solid Anti-rust Preparation.—Dry tallow, 25 parts; white wax, 23 parts; olive oil, 22 parts; oil of turpentine, 25 parts; mineral oil, 10 parts. Apply with a brush at the fusing temperature of the mixture.—Farben Zeitung.

Detection of Counterfeit Bank Notes.—To ascertain whether a French bank note is genuine or counterfeit, a blank part of the note is rubbed with a silver coin; or a mark is drawn on the note with a piece of silver. If the mark is black, the note is genuine; otherwise, it is counterfeit. This results from the chemical composition contained in the paper pulp from which the notes are made.—Le Matin.

To Improve the Odor of Carbon Sulphide.—Add to carbon sulphide one per cent of corrosive sublimate, and let stand, but stirring from time to time for several days. Then distill. The liquid obtained has a much less disagreeable odor than the original carbon sulphide.

An excellent result may also be secured by mixing with the sulphide one-third in volume of the oil of bitter almonds. The distilled sulphide has then an agreeable etherized odor.—Chemiker Zeitung.

Preventing the Putrefaction of Strong Glues.—The fatty matter always existing in small quantity in sheets of ordinary glue deteriorates the adhesive properties and facilitates the development of bacteria, and consequently putrefaction and decomposition. These inconveniences are remedied by adding a small quantity of caustic soda to the dissolved glue. The soda prevents decomposition absolutely; with the fatty matter it forms a hard soap, which renders it harmless.—Revue des Produits Chimiques.

Clarification of Honey.—For 3 kilogrammes of fresh honey, take 875 grammes of water, 150 grammes of washed, dried and pulverized charcoal, 70 grammes of powdered chalk, and the whites of three eggs beaten in 90 grammes of water. Put the honey and the chalk in a vessel capable of containing one-third more than the mixture and boil for three minutes; then introduce the charcoal and stir up the whole. Add the whites of the eggs while continuing to stir, and boil again for three minutes. Take from the fire and after allowing the liquid to cool for a quarter of an hour, filter, and to secure a perfectly clear liquid refilter, on flannel.—Le Lait.

A Liquid for Polishing Metals.—I. Melt 8 parts of paraffine and work into it 16 parts of rotten stone. To this add when cold 16 parts of common petroleum and a little of the oil of mirbane. II. Pulverize ½ part of crystals of oxalic acid, and mix it with 10 parts of rotten stone; now melt 2 parts only of paraffine, which are to be added to 30 parts of petroleum, and mix the powdered ingredients with this, adding a little oil of lavender. III. Mix together 2 parts of powdered pumice stone, as much of rotten stone, and the same quantity of iron carbonate. Now melt 2 parts of paraffine, which is thrown while still hot into 16 parts of petroleum oil, to which the solid powders just prepared are added and well stirred in.—Nouvelles Scientifiques.

For Cleaning Silverware.—Mix 2 parts of beechwood ashes with 4-100 of a part of Venetian soap and 2 parts of common salt in 8 parts of rain water. Brush the silver with this, using a pretty stiff brush. A solution of crystallized permanganate of potash is often recommended, or even the spirits of hartshorn, for removing the grayish violet film which forms upon the surface of the silver. Finally, when there are well-determined blemishes upon the surface of the silver, they may be soaked four hours in soap maker's lye, then cover them with finely-powdered gypsum which has been previously moistened with vinegar, drying well before a fire; now rub them with something to remove the powder. Finally, they are to be rubbed again with very dry bran.—Metallarbeiter.

Inexpensive Electric Battery.—We give herewith for amateurs or those using electricity on a small scale two receipts, which will enable them to make a battery at low cost, but sufficient for an electric bell, an office telephone, or for other limited use.

First Receipt.—Mix equal parts of manganese peroxide, in pieces the size of a pea, with coke or retort coal, also in small pieces. Put the whole in a wire-cloth bag, and in the middle a piece of retort coal. Tie the upper part of the bag and immerse in a preserve kettle or jar containing a solution of chlorhydrate of ammonia and a piece of zinc.

Second Receipt.—Take a porous vessel of about 0.15 meter in diameter and pile up around a piece of charcoal small pieces of coke mixed with a little chloride of lime. Add a little melted pitch in order to avoid the odor of chlorine. Put in an outer vessel salted water (240 grammes of pure kitchen salt to 1 liter of water) and a piece of zinc. A little salted water four times a year is sufficient for this battery.—Journal de l'Electrochimie.

SELECTED FORMULÆ.

To Fasten Wood and Glass to Metal.—Grind together 2 parts of protoxide of lead (litharge) and 1 part of white lead in 6 parts of boiled linseed oil, to which add 6 parts of copal varnish.—Practische Wegweiser.

Cucumber Cream.—Mix together 3 parts of white wax, 3 parts of spermaceti, 8 parts of benzoin lard, and 3 parts of cucumbers. The cucumbers are cut up small and shaken into the mixture of the other ingredients. Now stir it until it becomes cold, and let it stand about 24 hours, melt it again, and strain it, stirring again until cold.—Drog. Rundschau.

Liquid Soaps.—According to credible authority, these soaps can only be obtained by treating hard soaps with a base of pure olive oil, which are dissolved in alcohol with the final addition of a certain quantity of potassium carbonate. Grate the soap fine and put it into a receptacle over a water bath, together with the alcohol and the carbonate, stirring constantly and letting the temperature rise little by little. At the end of at least an hour the solution is complete, and perfectly transparent if white soap has been used. Perfume may be added to suit the taste, but it must be done at the moment when the decoction is removed from the bath. The alcohol used ought to be 80 deg. proof.—Nouvelles Scientifiques.

Perfuming and Coloring of Toilet Soaps.—

Jockey Club Soap.

White ground soap	50 kilos.
Artificial oil of neroli	100 grammes.
Oil of bergamot	100 grammes.
Terpineol	80 grammes.
Artificial musk	15 grammes.
Oil of orange berries	75 grammes.
Heliotropine	100 grammes.
Iso-eugenol	20 grammes.
For coloring:	
Wax yellow	10 grammes.
Rhodamine	3 grammes.

Mimosa Soap.

White ground soap	50 kilos.
Mimosa	200 grammes.
Vanilline	10 grammes.
Oil of bergamot	40 grammes.
Oil of orris	10 grammes.
Artificial musk	2 grammes.
For coloring:	
Fine pink	80 grammes.

—From the French of H. Ziolkowsky in La Perfumerie Moderne.

Triple and Quadruple Extracts.—

Royal Amber.

Infusion of amber	1,000 grammes.
Infusion of musk	500 grammes.
Tincture of rose	500 grammes
Tincture of jasmine	500 grammes.
Artificial musk	10 grammes.
Tincture of vanilline	500 grammes.
Infusion of benzoin	300 grammes.

Gardenia (Cape Jasmin).

Infusion of rose	1,500 grammes.
Infusion of violet	500 grammes.
Infusion of tuberose	500 grammes.
Tincture of vanilline	250 grammes.
Eglantine	20 grammes.
Hawthorn	5 grammes.
Terpineol	30 grammes.
Artificial neroli	5 grammes.
Infusion of musk	30 grammes.

French Heliotrope.

Tincture of heliotropine	1,600 grammes.
Tincture of vanilline	2,400 grammes.
Extract of mignonette	2,500 grammes.
Extract of ylang-ylang	100 grammes.
Extract of musk	1,500 grammes.
Tincture of jasmine	1,000 grammes.

Royal Cologne Water.

Alcohol	23,000 grammes.
Oil of lemon	350 grammes.
Oil of bergamot	300 grammes.
Oil of lavender	20 grammes.
Oil of peppermint	12 grammes.
Acetic ether	12 grammes.
Artificial oil of neroli	5 grammes.
Oil of thyme, white	5 grammes.
Oil of rosemary	5 grammes.
Artificial oil of rose	3 grammes.
Rose water	200 grammes.
Orange flower water	2,000 grammes.

Shampooing Liquid.

Distilled water	10,000 grammes.
Alcohol	5,000 grammes.
Sal ammoniac	150 grammes.
Bicarbonate of soda	600 grammes.
Oil of bergamot	25 grammes.

Shampooing Powder.

Bicarbonate of soda	500 grammes.
Carbonate of ammonia	50 grammes.
Borax	50 grammes.

Perfume as desired; for example, take 1,000 grammes of the above powder and add to it:

Oil of bergamot	20 grammes.
Oil of cananga	15 grammes.
Ionone	3 grammes.

—From the French of H. Ziolkowsky in La Perfumerie Moderne.

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